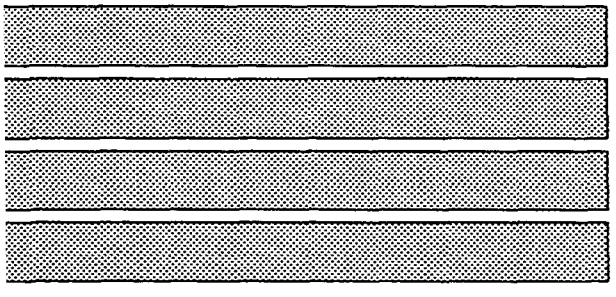
Contract Report 575

Installation and Operation of a Raingage Network for the Imperial Valley Water Authority Year One: September 1992 - August 1993

by Randy A. Peppier, Office of Special Programs
and Steven E. Hollinger, Office of Applied Climatology

Prepared for the
Imperial Valley Water Authority

October 1994



Illinois State Water Survey
Atmospheric Sciences Division
Champaign, Illinois

A Division of the Illinois Department of Energy and Natural Resources

INSTALLATION AND OPERATION OF A RAINGAGE NETWORK FOR THE IMPERIAL VALLEY WATER AUTHORITY YEAR ONE: SEPTEMBER 1992 - AUGUST 1993

Randy A. Peppier

and

Steven E. Hollinger

REPORT

to

Imperial Valley Water Authority

on Contract

Imperial Valley 223

Steven E. Hollinger and Randy A. Peppier
Co-Principal Investigators

Atmospheric Sciences Division
Illinois State Water Survey
2204 Griffith Drive
Champaign, Illinois 61820-7495

October 1994

This report was printed on recycled and recyclable papers.

CONTENTS

INSTALLATION AND OPERATION OF A RAINGAGE NETWORK FOR THE IMPERIAL VALLEY WATER AUTHORITY YEAR ONE: SEPTEMBER 1992 - AUGUST 1993

1. INTRODUCTION

Regional precipitation variability affects irrigation water demand on an aquifer, the recharge of the aquifer, and the density of wells and irrigation systems required for successful agriculture and water supplies. These factors all impact any required water withdrawal allocations from an aquifer. Therefore, knowledge of the precipitation variability over a highly-irrigated region, such as the area within the Imperial Valley Water Authority (IVWA), should provide useful information for the management of ground-water resources in that region.

At present, the measurement of precipitation is best accomplished by deployment of a network of raingages of sufficient areal density for a long period of time. A relatively dense raingage spacing is needed to capture both summertime convection, which can be quite variable, and more widespread wintertime events. A relatively long time period is necessary to capture short-term climatological shifts, such as abnormally wet or dry periods, and even normal periods. Such networks provide the data necessary to understand the variability of precipitation patterns both spatially and temporally, and thus the spatial and temporal variations in the recharge of soil and ground water within the network area. The data help identify the extent of areas susceptible to heavy irrigation water use and/or areas of poor recharge. Combined with ground-water data, these precipitation data can provide the inputs needed for estimates of recharge to the ground-water resources within the network area.

During the last 40 years, the Illinois State Water Survey (ISWS) has operated raingage networks of varying areal gage densities over various time periods in both rural and urban areas.

Sampling requirements, as determined from these past studies (e.g., Huff, 1970), indicate that a 2- to 3-mile gridded raingage spacing should be adequate for properly capturing convective precipitation systems (spring and summer), while a 6-mile spacing is adequate for more widespread precipitation-producing systems (fall and winter). Compromises within these ranges are acceptable in a rural setting. The weighing-bucket raingage, used by the National Weather Service (NWS), has been determined to provide precise and reliable precipitation measurements. Given the size of the IVWA area and the above spacing guidelines, a gridded, 25-site raingage network with approximately 5 miles between gages was proposed.

The ISWS itself has a long-term interest in precipitation measurement and related research, and has performed precipitation research in areas such as hydrology, weather modification, and urban influences on precipitation climate. The data collected by a raingage network such as the IVWA Network would be used in similar research.

An agreement was reached between the IVWA and the ISWS in the spring of 1992, and the 25-site network was deployed in late August 1992. This report documents the construction, operation, maintenance, data reduction, and management of this network during its first year of operation (September 1992 through August 1993). The report also provides data analyses for the year. Several appendices document the actual raingage sites, instructions for raingage technicians, raingage maintenance, unusually large precipitation amounts recorded during the year, and monthly precipitation variability at each of the sites.

2. NETWORK DESIGN

Figure 1 shows the layout of the raingage network designed and deployed during me summer of 1992. The 5-mile spacing used is similar to the spacing being used in Cook County,

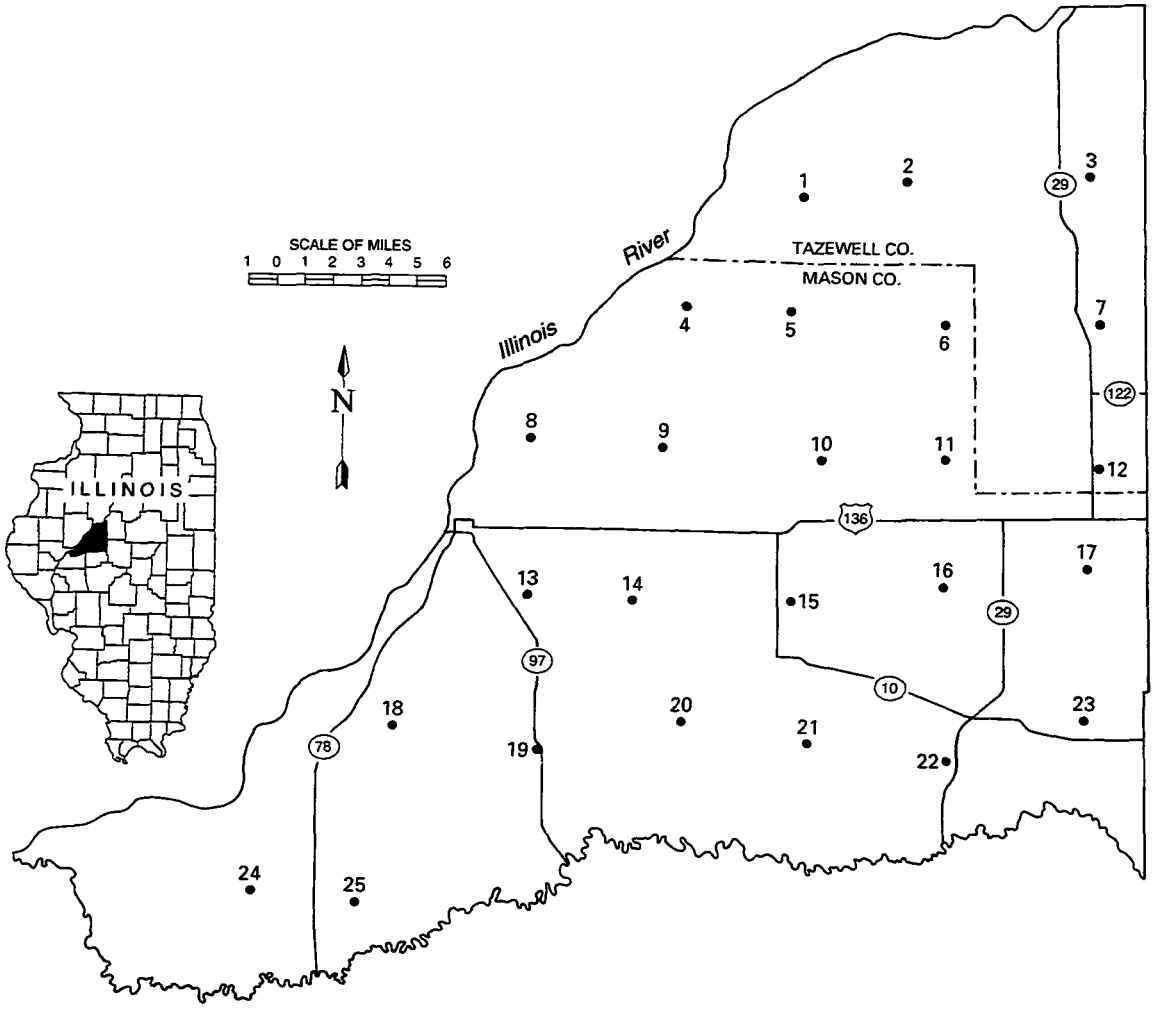


Figure 1. Configuration of the 25-site Imperial Valley Water Authority raingage network

Illinois, for a 25-site raingage network operated for the U.S. Army Corps of Engineers. The network there has provided adequate coverage for precipitation catchment during its first five years of operation (Peppier 1991b, 1991c, 1993b, 1994).

Topographic and land-use maps of the IVWA region were used to approximate the location of each of the 25 sites. Minimal terrain effects in the IVWA area made gridding of the network possible. Gridding also allows the use of simple arithmetic averages to compute areal depths instead of other labor-intensive methods such as the Thiessen polygonal method. Once candidate locations were found, two field trips were made to the IVWA region in early August 1992 to identify precise sites and seek permission for installing the raingages. Due to the rural nature of the region, site selection was fairly easy; most sites were found at the very first location visited. When selecting sites, highest priority was given to those where ground-level placement was possible in open, relatively secure areas with minimum obstructions by trees and buildings which cause local wind eddies. Placing the collector at ground level helps minimize wind effects on catchment and represents the "ideal" exposure (Legates and Willmott, 1990), but this is not practical in wintertime when snow is measured. Thus, as has been standard ISWS practice, each raingage was placed on stakes with its base approximately 8-12 inches above ground level and the opening at the top of me raingage about 4 feet above ground level. When asked for permission to site a raingage on their property, most individuals and businesses were very receptive.

After all sites were located, the raingages were deployed as indicated in Figure 1 in late August 1992. Other than some minor relocation of a few gages within their original properties, only one gage (Site #9) has been moved an appreciable distance (about 1.0 mile south) since the network was deployed.

Each universal weighing-bucket raingage used throughout the network was fitted with a spring-driven chart drive which can run from 7 to 12 days before rewinding is needed. The ISWS provided all raingages from its inventory. The weighing-bucket raingage used in the network, as mentioned previously, is at least as reliable as any others available (see Jones, 1969, for a complete description of reliability and measurement tests of different raingages). All raingages are subject to catchment errors due to winds, wetting losses, evaporation, splashing into or out of the gage, and blowing snow (Legates and Willmott, 1990). Koschmieder (1934) noted that as wind speeds increase, gage catchment decreases. Legates and Willmott (1990) found that raingage errors "tend to be proportional to total precipitation and amount to nearly 11 percent of the catch." To prevent loss due to blowing snow during the winter, the Nipher shield and the shield used by Lindroth (1991) have been found to be helpful, but were not considered for this network due to cost and vandalism concerns, and because they are difficult to remove during routine servicing.

Table 1 lists the property owner and address for each raingage site. Appendix I contains complete site description information for each location, current as of July 1, 1994.

Table 1. Raingage Network Site Information

Site Number	*Mame*	*Address*
1	Private Residence	10200 Fornoff Road Manito, IL 61546
2	Private Residence	8479 Townline Road Manito, IL 61546
3	Private Residence	RR#3, 11177 S. 14th Street Pekin, IL 61554
4	Ellis Popcorn	RR #1 Topeka, IL 61567
5	Private Residence	RR#1, Box 175 Topeka, IL 61567
6	Private Residence	c/o RR #3, Box 116 Manito, IL 61546
7	Private Residence	5801 Warner Road Green Valley, IL 61534
8	Private Residence	RR #2, Box 165 Havana, IL 62644
9	Private Residence	Box 19 Topeka, IL 61567
10	Private Residence	RR#1, Box 31 Forest City, IL 61532
11	Private Residence	32972 E. County Road 1900N Manito, IL 61546
12	Private Residence	1327 Route 29 San Jose, IL 62682
13	Private Residence	RR#1, Box 386 Havana, IL 62644
14	Private Residence	RR #1, Box 220 Easton, IL 62633
15	Private Residence	c/o RR #1, Box 156 Easton, IL 62633

Table 1. (Concluded)

Site Number	*Name*	*Address*
16	Private Residence	32866 E. County Road 1450N Mason City, IL 62664
17	Private Residence	RR#1, Box 100 San Jose, IL 62682
18	Private Residence	RR#1 Bath, IL 62617
19	Private Residence	RR #1, Box 51 Kilbourne, IL 62655
20	Private Residence	RR #1, Box 109 Easton, IL 62633
21	Private Residence	28030 E. County Road 850N Mason City, IL 62664
22	Private Residence	RR #2, Box 182 Mason City, IL 62664
23	Private Residence	RR#1, Box 149 Mason City, IL 62664
24	Private Residence	RR#1, Box 147 Bath, IL 62617
25	Adkins Farms	RR #2, Box 16 Chandlerville, IL 62627

3. NETWORK OPERATION AND MAINTENANCE

Each raingage in the network is fitted with 24-hour chart drive and chart cylinder gears that rotate the chart cylinder once every 24 hours. The 24-hour chart allows resolution down to 15-mimite periods. Because a chart can measure up to 12 inches of precipitation, each gage is fitted with a galvanized bucket capable of holding 12 inches in calibration with an 8-inch opening on top of the raingage collector. An upward pen traverse on the chart measures the first 6 inches of catchment, while a reversed downward pen traverse measures another 6 inches. The downward traverse is vital whenever more than 6 inches of precipitation occurs between chart periods, or during winter when antifreeze is kept in each raingage bucket to allow precipitation to accumulate without freezing (the antifreeze/precipitation mixture is kept in the bucket for long periods of time without dumping, thus necessitating the need for a full 12-inch range on the chart).

Though it was hoped that a local observer could be found for each raingage site to perform the weekly servicing, only 11 such local observers actually perform this task; the other 14 are done by an experienced raingage technician headquartered in Champaign. Nevertheless, each raingage is serviced every 6 to 9 days, which means that 6 to 9 traces are drawn on each chart. Servicing includes removing and replacing the current chart, checking the felt-tipped pen to make sure it is inking properly, dumping the bucket contents from approximately April-October, and noting any unusual problems, including chart-drive malfunction, gage imbalance or instability, vandalism, unauthorized movement of the gage, etc. During the warm season, evaporation shields are fitted into the collection orifice above the bucket to minimize evaporation. During the cool season (November-March), these shields are removed and a one-quart charge of antifreeze is added to each bucket. Refer to Appendix II for a complete listing

of servicing instructions for raingage observers.

Approximately once a week a complete set of 25 charts is mailed and/or delivered by the Champaign-based technician to the ISWS. The following section describes what happens to the data collected on the charts.

The ISWS project leader visits the network as needed to perform unusual maintenance and repairs, though the Champaign-based technician can handle most of these duties. These visits usually involve a site assessment of an observer-noted problem and the determination of a solution. Because most problems pertain to the chart drives, the solution is often to adjust or replace the chart drive. If replaced, the defective chart drive is cleaned and readied for reuse at the ISWS. Other typical problems, mentioned above, can usually be solved on these trips. Appendix HI gives a complete maintenance history, including site relocations, for each of the 25 raingages and more fully describes the kinds of maintenance and repairs conducted. This information is listed through August 31, 1993.

4. DATA REDUCTION

When raingage charts arrive at the ISWS, they are edited to identify the various traces on the charts and to number sequentially by date those showing precipitation. This is perhaps the most important step in the reduction procedure. A running inventory of "on" and "off" chart times is also maintained to ensure that the on-times on the newly received charts match the off-times on the last set of charts analyzed. Occasionally, inadvertent errors are made in the on-/off-time designations, particularly when time zones change in October and March (charts are always kept on Central Standard Time). The on- and off-times are marked on the charts, with the on-time revolution designated as " 1 " and the last revolution designated as appropriate. Then,

the various rain periods (storms) are identified and numbered based on their sequence in relation to the first and last revolutions. This editing procedure also acts as a trouble-shooting exercise to identify chart-drive problems (running slow, fast, or not at all). Raingage instability can be identified by a shaky pen trace. Skipping or unusually heavy traces indicate problems with the pen tip. Calibration problems can be noted if a trace reverses before or after the 6-inch line at the top of the chart is reached. Finally, the editing stage permits the identification of missing periods of data on the charts, and these are appropriately noted. After all charts have been edited, they are ready to be digitized with a Summagraphics Microgrid II Digitizer.

All data values are fed into a 486/33 Mhz personal computer via the digitizer. Each chart is processed separately. The four corners of each chart are digitized to set the grid, then on- and off-times are entered by hand and their locations are digitized. The number of revolutions on each chart is also entered. Each trace indicating precipitation is digitized separately by "clicking" on each breakpoint along the respective trace. Once a chart is digitized, computer output gives details on the precipitation that was measured on the chart, in storm amount format, with appropriate beginning and ending times. Also included is an analysis of whether the chart drive was running too slow or too fast, which helps assess whether a chart drive requires servicing. Errors made during the editing stage can also be caught during digitizing. If a chart drive stops during a collection period, the beginning and ending points of the missing period are digitized and appropriately stored in the computer.

Once a calendar month of data is logged into the computer, a C-language program, written at the ISWS, calculates hourly precipitation values at all 25 sites for each hour of the month in question. These calculations are based on a linear interpolation between digitized breakpoints on the traces. The newly computed hourly values are compared to the digitized

storm values to ensure consistent precipitation amounts. A printout of the monthly data array includes data for all 25 stations for all hours of the month. Monthly totals appear at the bottom of the printout. Missing values are denoted as 99.99.

This data array is then used to check for time and space consistency between raingages, to divide the data into storm periods, and to fill in missing values with estimates. A storm is defined as a precipitation period separated from preceding and succeeding precipitation periods across the entire network by approximately 6 hours. This definition has been used by Huff (1967) for an area of similar dimensions in central Illinois, by Vogel (1986) to define extreme storm events in the Chicago area, and by Vogel (1988, 1989) and Peppier (1990, 1991a, 1991b, 1991c, 1993a,b, 1994) to define storm events during 1984-1993 in the Cook County area. For each storm, values are summed and plotted on maps using all available data and stations, and isohyetal patterns are drawn. During the first year of operation of the IVWA Network, 128 such storms were identified.

After a generalized precipitation pattern is obtained for each storm, interpolated storm totals are figured from the pattern for each site having missing information and used as preliminary estimates for me missing values. A computer program that uses an objective analysis program from the International Mathematical and Statistical Library (IMSL) is then executed to objectively determine new values for hours designated as missing. This program is also used to re-create values at data sites with questionable values that were identified during the storm analysis stage. After execution of the program, the computer-generated values are compared to the preliminary estimates, and unrealistic computer values are adjusted to better fit the manual estimates. Once everything has been verified, a final data file of hourly precipitation values for the month is archived.

5. DATA ANALYSIS AND METHODOLOGIES

Table 2 contains monthly and annual (September 1992-August 1993) precipitation totals for each site in the IVWA Network. Corresponding analyses of this precipitation are contained in Figure 2 (annual) and Figures 3-8 (monthly). Table 2 and Figure 2 show that totals for the year ranged from 60.15 inches at Site #19 just north of Kilbourne to 48.05 inches at Site #23 east of Mason City. Fifteen of the 25 sites reported precipitation in excess of 55 inches. All of these amounts were unusually large for me region as compared to long-term normals at the Havana and Mason City NWS cooperative stations, which are 37.24 and 35.08 inches, respectively, for the period 1961-1990. The network average for the year was 55.55 inches, which is 49 percent and 58 percent, respectively, above the 30-year averages for Havana and Mason City. Annual totals were largest in the southwestern portion of the network centered on Site #19 near Kilbourne and extending northeastward to Site #11 in northeastern Mason County. Lower values occurred in three areas: in the southeast near Mason City at Sites #21, #22 and #23; southeast of Manito centered on Site #6; and in the west from Site #8 northeast of Havana southwestward towards Site #25 near Saidora.

Monthly analyses in Figures 3-8 (see Table 2 for specific amounts) show that July 1993 (Figure 8) was by far the wettest month during the first year of network operation (11.05-inch network average), followed by November 1992 (6.35-inch network average, Figure 4), June 1993 (6.27-inch network average, Figure 7), and August 1993 (5.99-inch network average, Figure 8). April 1993 (Figure 6) also exceeded 5 inches over the network, with an average of 5.25 inches. This heavy precipitation, particularly beginning in April and continuing through the summer (with a slight respite in May - Figure 7), contributed to the widespread flooding during the summer of 1993 in western and southwestern Mason County (overflow of the

Table 2. Monthly and Year One Precipitation Amounts For September 1992-August 1993 (inches)

	Site Number																							
Date	**1**	**2**	**3**	**4**	**5**	***6***	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Sep-92	4.14	4.07	3.45	5.29	5.03	4.29	3.65	4.40	4.44	4.69	5.01	3.78	3.95	4.45	4.52	4.33	3.44	4.38	4.41	4.01	3.80	3.95	3.43	4.66	3.73
Oct-92	2.00	1.83	1.55	2.01	2.04	2.08	1.69	1.92	2.16	2.54	2.50	2.18	1.57	2.03	2.15	2.16	2.19	1.68	1.78	1.73	1.79	2.23	2.50	1.83	1.92
Nov-92	5.73	5.17	5.60	5.48	6.58	6.55	5.39	5.84	6.21	7.75	7.61	6.39	6.57	5.67	7.30	6.34	6.90	5.69	7.84	6.74	6.62	6.06	5.71	5.99	6.90
Dec-92	2.85	2.75	2.75	2.91	2.80	2.72	2.64	2.75	2.99	2.93	3.18	2.43	3.09	3.03	2.73	2.62	2.52	2.75	3.27	2.82	2.80	2.91	2.72	2.88	2.57
Jan-93	3.64	3.57	3.55	3.23	3.39	3.47	3.20	3.13	3.44	3.49	3.82	3.33	3.45	3.51	3.28	3.59	3.90	2.83	3.88	3.96	3.68	4.08	3.78	3.39	3.44
Feb-93	2.00	1.24	1.10	1.66	1.61	1.69	1.13	1.35	1.47	1.72	2.23	1.90	1.86	1.77	1.63	1.73	1.95	1.35	2.50	1.41	1.33	1.37	1.56	1.47	1.90
Mar-93	3.98	3.28	3.08	4.16	4.04	3.56	3.06	4.08	4.25	4.04	4.05	3.23	4.36	4.10	3.98	3.47	3.47	3.99	4.93	3.77	3.36	3.58	2.97	4.67	4.69
Apr-93	4.99	4.56	4.79	4.69	5.34	5.04	4.35	4.38	5.09	5.34	5.10	5.14	4.95	5.40	5.62	5.40	5.59	5.26	5.87	5.86	6.22	6.07	5.56	5.33	5.26
May-93	3.44	3.46	3.42	4.71	3.23	2.67	2.71	3.21	2.27	2.03	2.39	2.59	3.11	2.70	2.59	2.16	2.36	2.45	1.91	1.90	1.83	1.80	2.00	2.55	1.88
Jun-93	5.52	5.15	6.03	6.07	6.06	4.93	5.85	8.20	7.71	7.30	6.68	6.04	6.83	6.45	8.24	7.60	7.09	6.84	6.67	6.01	4.71	4.39	5.39	5.92	5.15
Jul-93	1.32	11.73	12.65	11.87	11.19	10.00	12.79	10.15	10.95	9.49	10.33	10.77	11.43	11.62	10.60	10.92	9.69	12.24	11.96	10.75	10.31	9.78	8.08	12.72	12.87
Aug-93	5.81	6.06	8.87	5.15	6.09	4.84	7.30	5.28	6.17	6.72	5.82	6.81	6.36	6.52	6.42	5.78	5.76	5.79	5.13	7.17	6.03	5.64	4.35	5.38	4.41
Year One	55.42	52.87	56.84	57.23	57.40	51.84	53.76	54.69	57.15	58.04	58.72	54.59	57.53	57.25	59.06	56.10	54.86	55.25	60.15	56.13	52.48	51.86	48.05	56.79	54.72

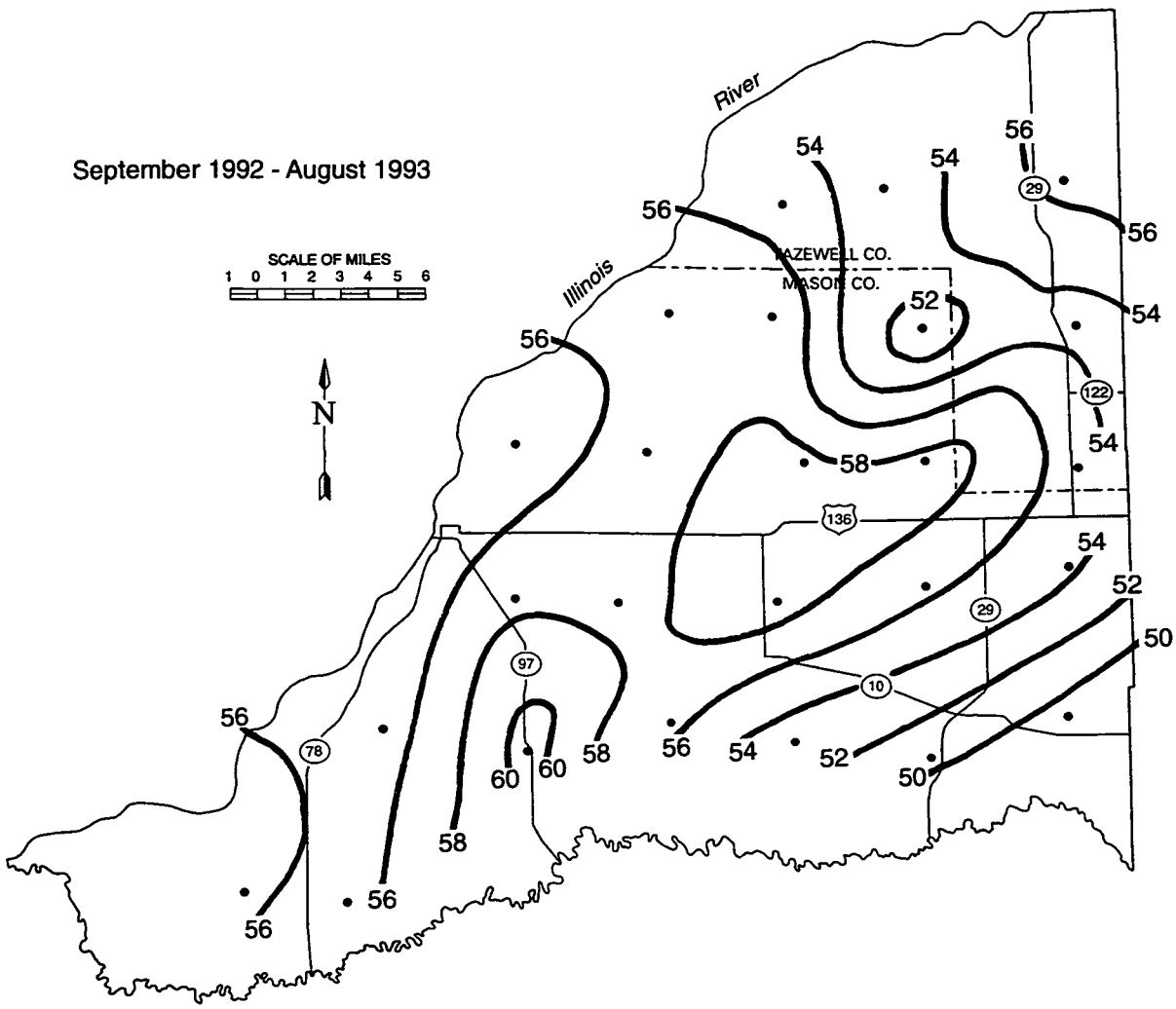


Figure 2. Precipitation in inches for September 1992-August 1993

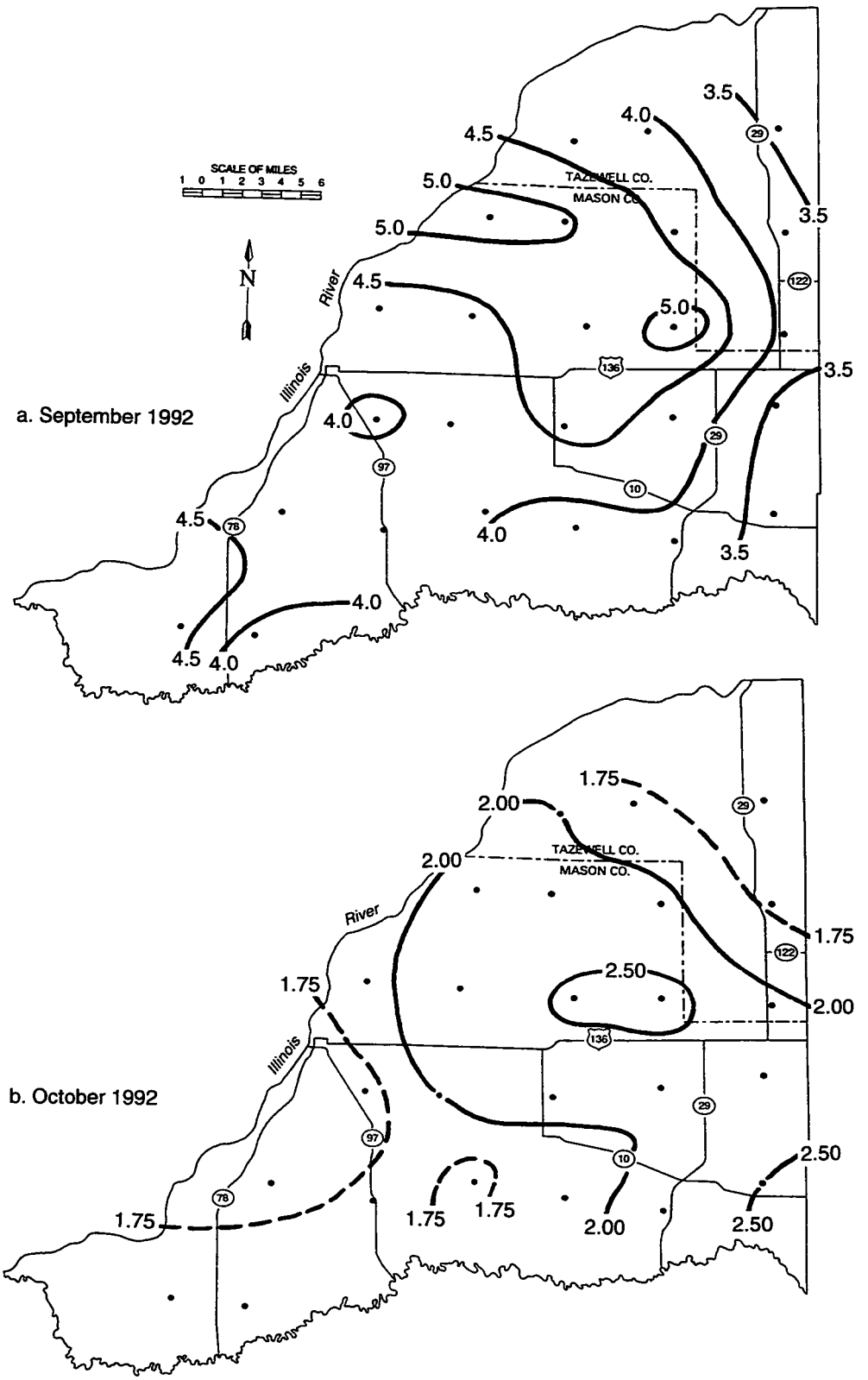


Figure 3. Precipitation in inches for September 1992 (a) and October 1992 (b)

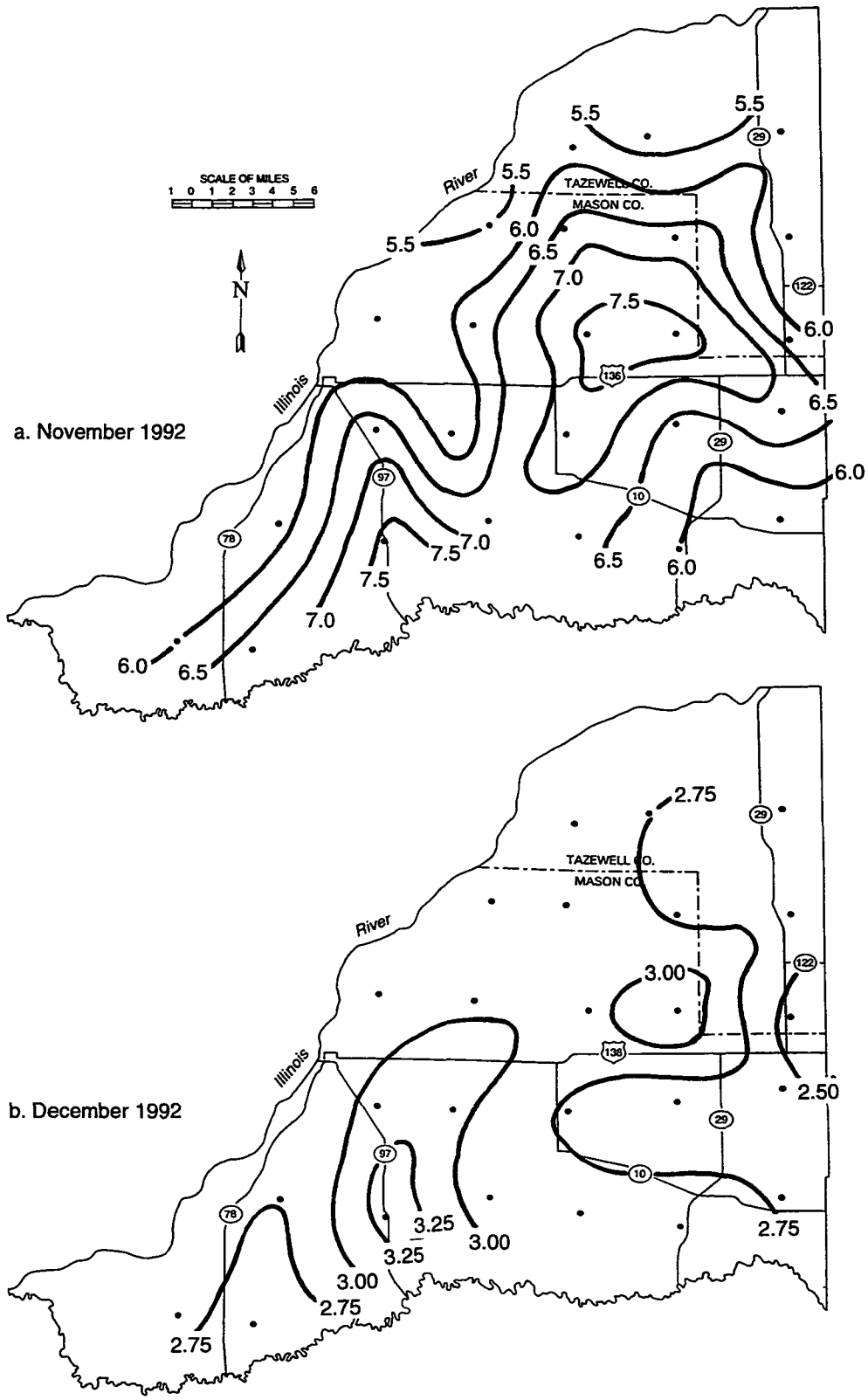


Figure 4. Precipitation in inches for November 1992 (a) and December 1992 (b)

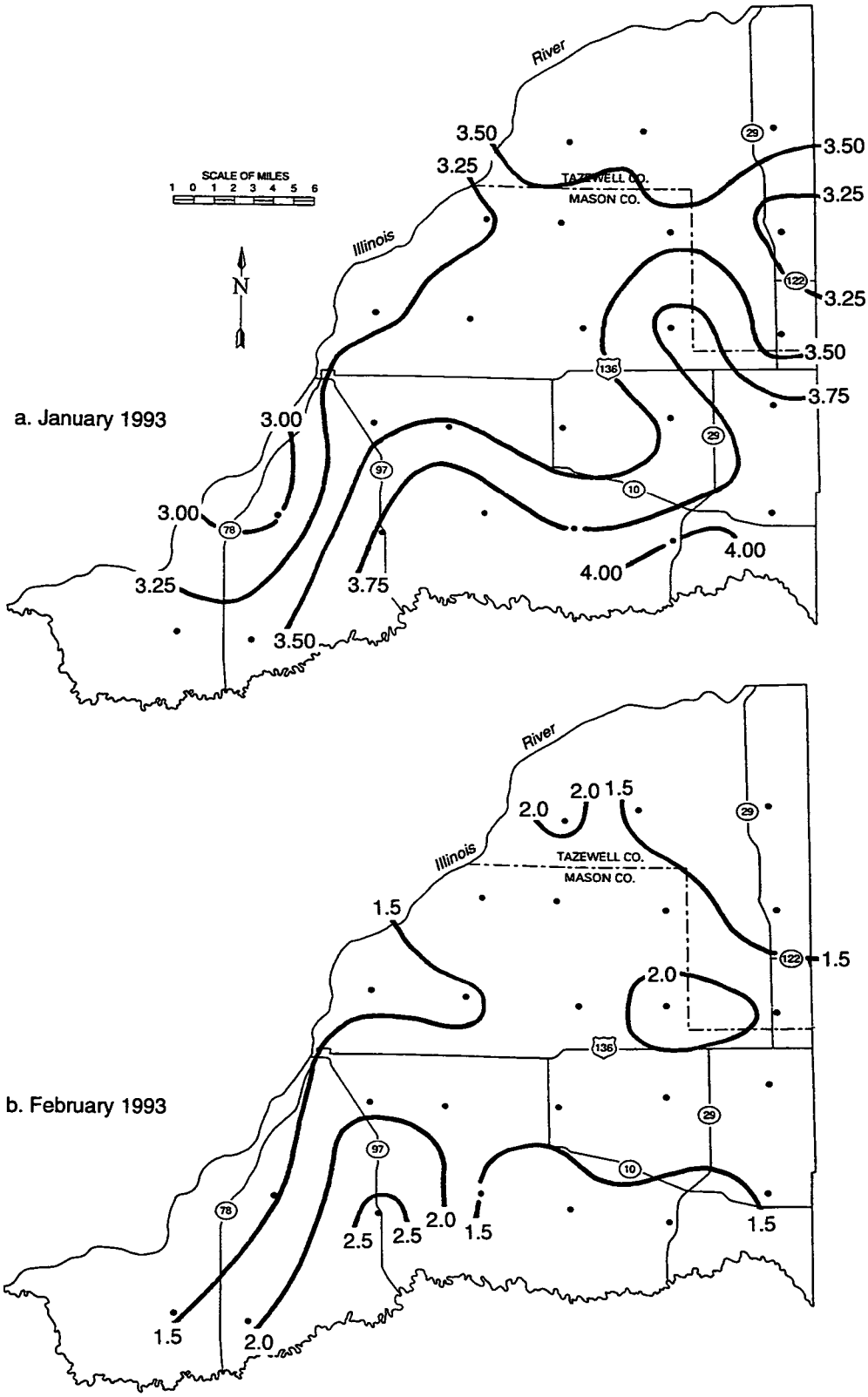


Figure 5. Precipitation in inches for January 1993 (a) and February 1993 (b)

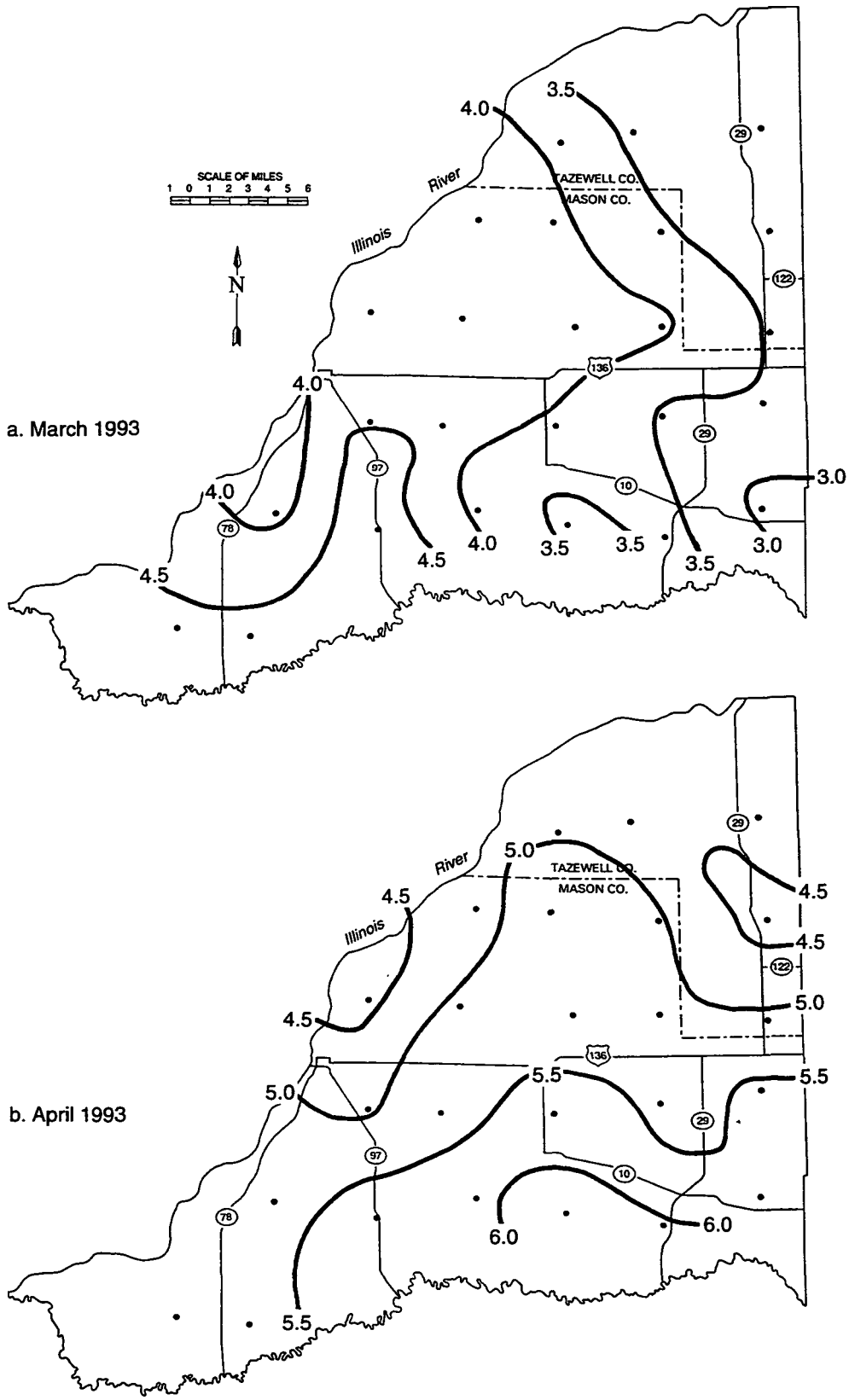


Figure 6. Precipitation in inches for March 1993 (a) and April 1993 (b)

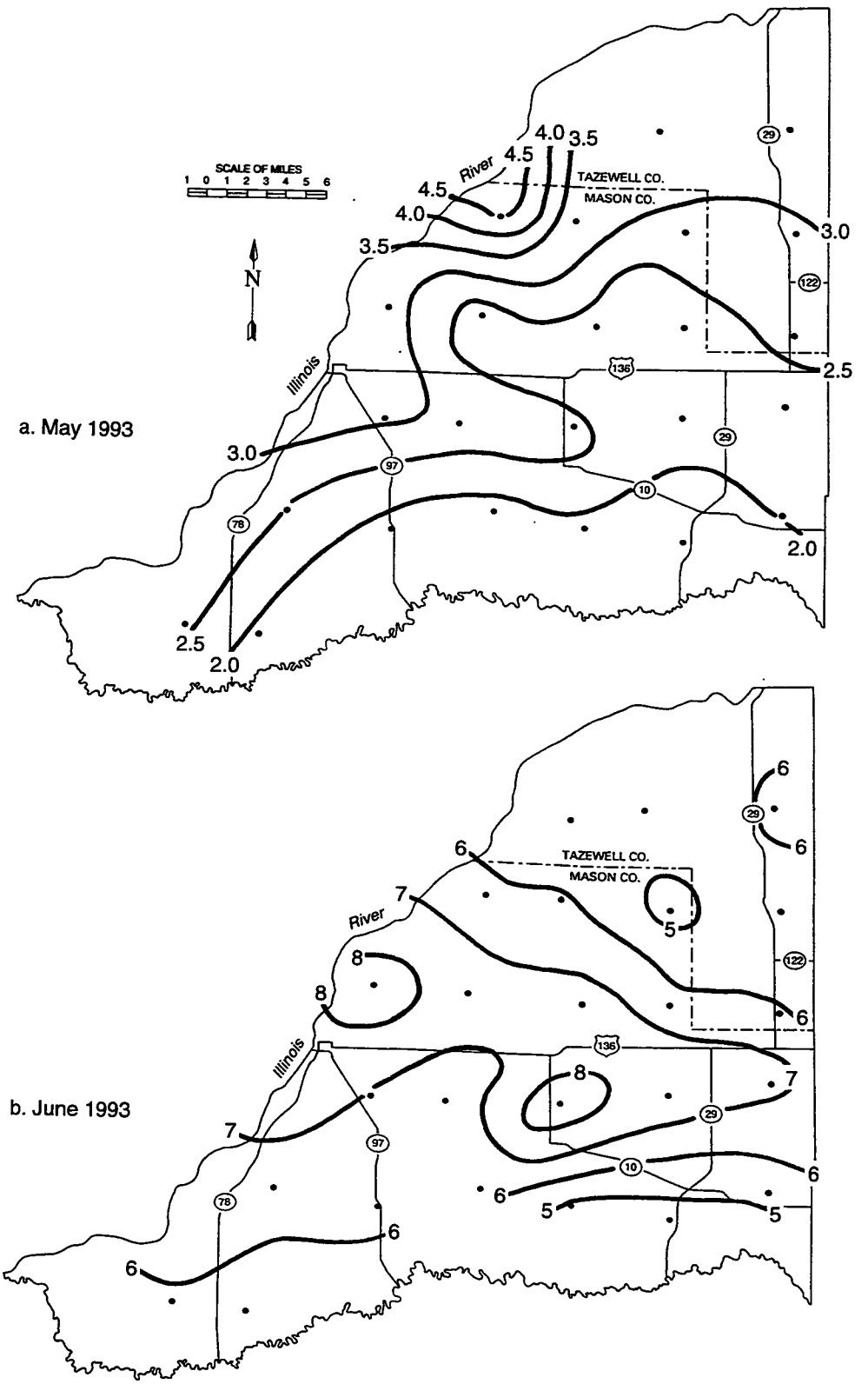


Figure 7. Precipitation in inches for May 1993 (a) and June 1993 (b)

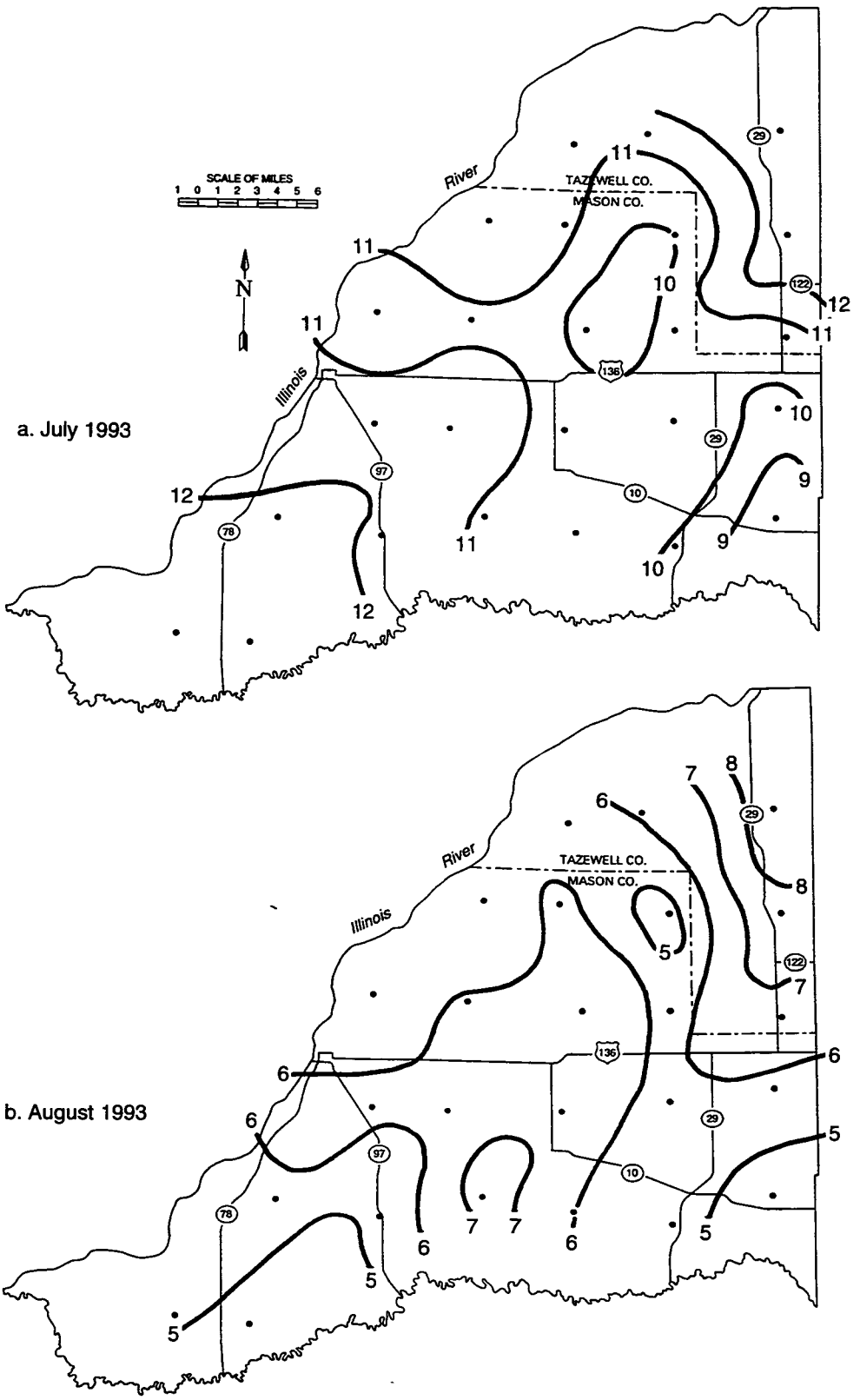


Figure 8. Precipitation in inches for July 1993 (a) and August 1993 (b)

underground aquifer) and in southwestern Tazewell County (flooding of the Mackinaw River Valley). During July, November, and August, the heaviest precipitation occurred in both western/southwestern Mason County and in northeastern Mason/southwestern Tazewell Counties, correlating closely with the flooded areas. In June the heaviest precipitation occurred just northeast of Havana, also coinciding with the western Mason County flooding, while in April the heaviest totals occurred in southern Mason County. Thus, in western and southwestern Mason County, there appears to have been a direct relationship between the unusually heavy precipitation and the ground-water recharge/overflow problem. This relationship will be discussed in more detail later in the report.

The few dry periods during the first year of network operation were recorded in February 1993 (1.64-inch average, Figure 5), October 1992 (2.00-inch average, Figure 3), May 1993 (2.61-inch average, Figure 7), and December 1992 (2.82-inch network average, Figure 4). The driest areas during these months were in southwestern Tazewell County (February and October), southern Mason County (February, October, and May), and in extreme southern Tazewell County near San Jose (December).

The three months not included in the above wet/dry discussions are January 1993 (3.52-inch network average, Figure 5), March 1993 (3.85-inch network average, Figure 6), and September 1992 (4.21-inch network average, Figure 3), respectively.

Figure 9 presents a special analysis of the June-September 1993 period, the wettest during the first year of network operation, plus the first month of the second year of operation. Precipitation across the area during this period alone matched or exceeded the long-term annual averages listed earlier for Havana and Mason City. Values ranged from 29 inches in the far southeast, east of Mason City, to more than 38 inches in the south-central portion of the

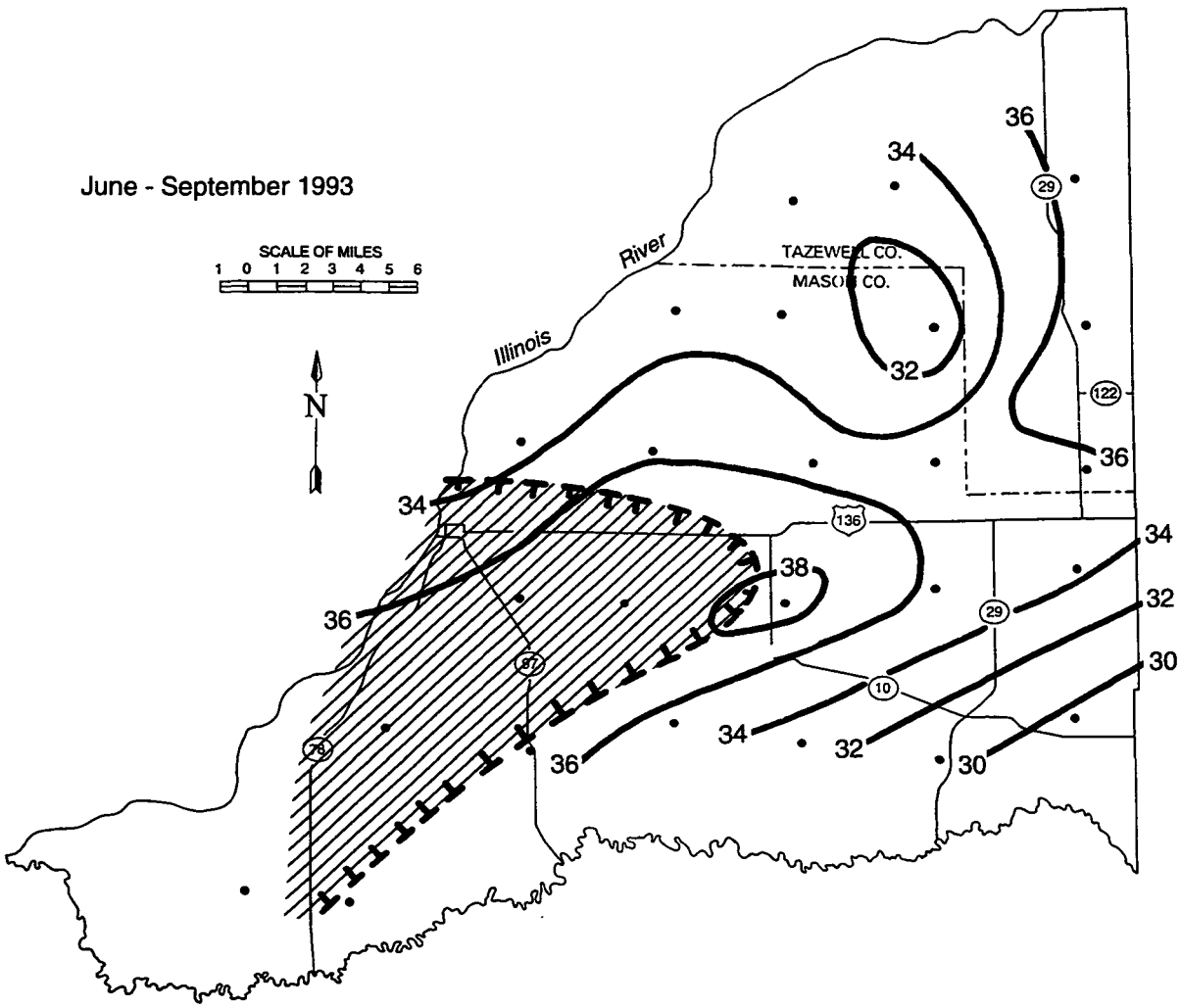


Figure 9. Precipitation in inches for June-September 1993
Hatched area indicates ground-water flooding

network. Values in excess of 36 inches were common over most of the southwestern third of the network and in the northeast. The ground-water flooding that occurred in Mason County, approximately shown by the hatched area in Figure 9, coincided closely with the heavy southwestern precipitation. Flooding of the Mackinaw River valley in southwestern Tazewell County occurred with the heavy northeastern precipitation.

Figure 10 gives a graphical view of the monthly variability of precipitation when the network-wide average is considered. The figure clearly shows that the latter end of the year, when the flooding occurred, was extremely wet. Similar graphs for each of the 25 raingage sites are located in Appendix IV.

Appendix V documents 12 individual significant storms that occurred during the year - Storms 4, 18, 78, 87, 90, 91, 96, 99, 106, 107, 111, and 124. These were storms that produced amounts in excess of an annual event at one or more stations (i.e., they produced so much precipitation that they should only occur once per year). Storms 90 (June 30, 1993) and 106 (July 23, 1993) deserve particular note, as each produced precipitation that exceeded a five-year event (i.e., an event that should occur only once every five years). For Storm 90 the event occurred at Site #16 northwest of Mason City, where 3.29 inches of rain fell in an eight-hour period, and for Storm 106 the event occurred at Site #18 near Bath, where 3.37 inches of rain fell in a ten-hour period. The largest storm amount of the year occurred during Storm 18 (October 31-November 2, 1992) at Site #11 in northeastern Mason County, where 3.39 inches fell over a 33-hour period, exceeding a two-year event. Not surprisingly, 6 of the 12 significant storms listed occurred in July 1993, the wettest month of the first year of network operation.

In a comparison of network precipitation to the water levels in a shallow ground-water well the ISWS operates near Snicarte in southwestern Mason County (Figure 11), it can be seen

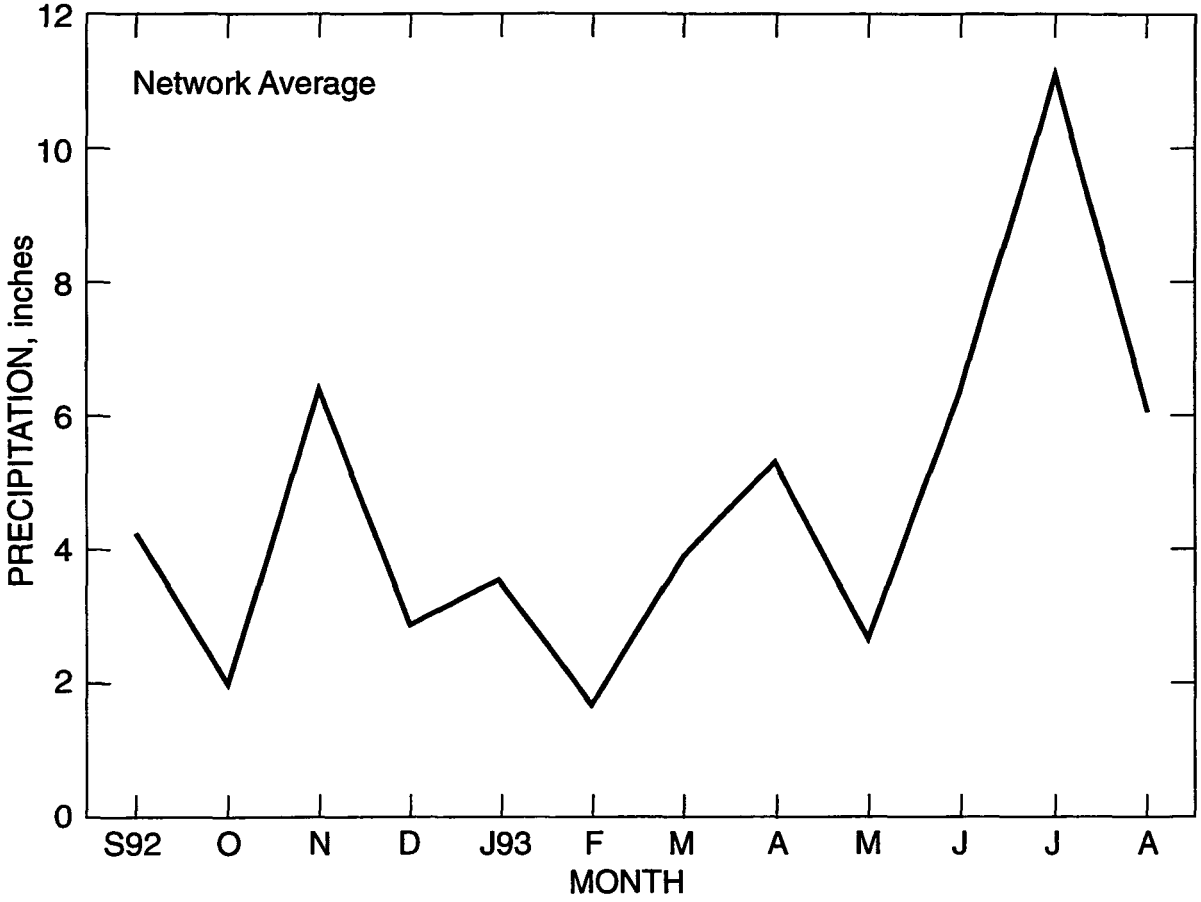


Figure 10. Monthly network-average precipitation in inches for September 1992-August 1993

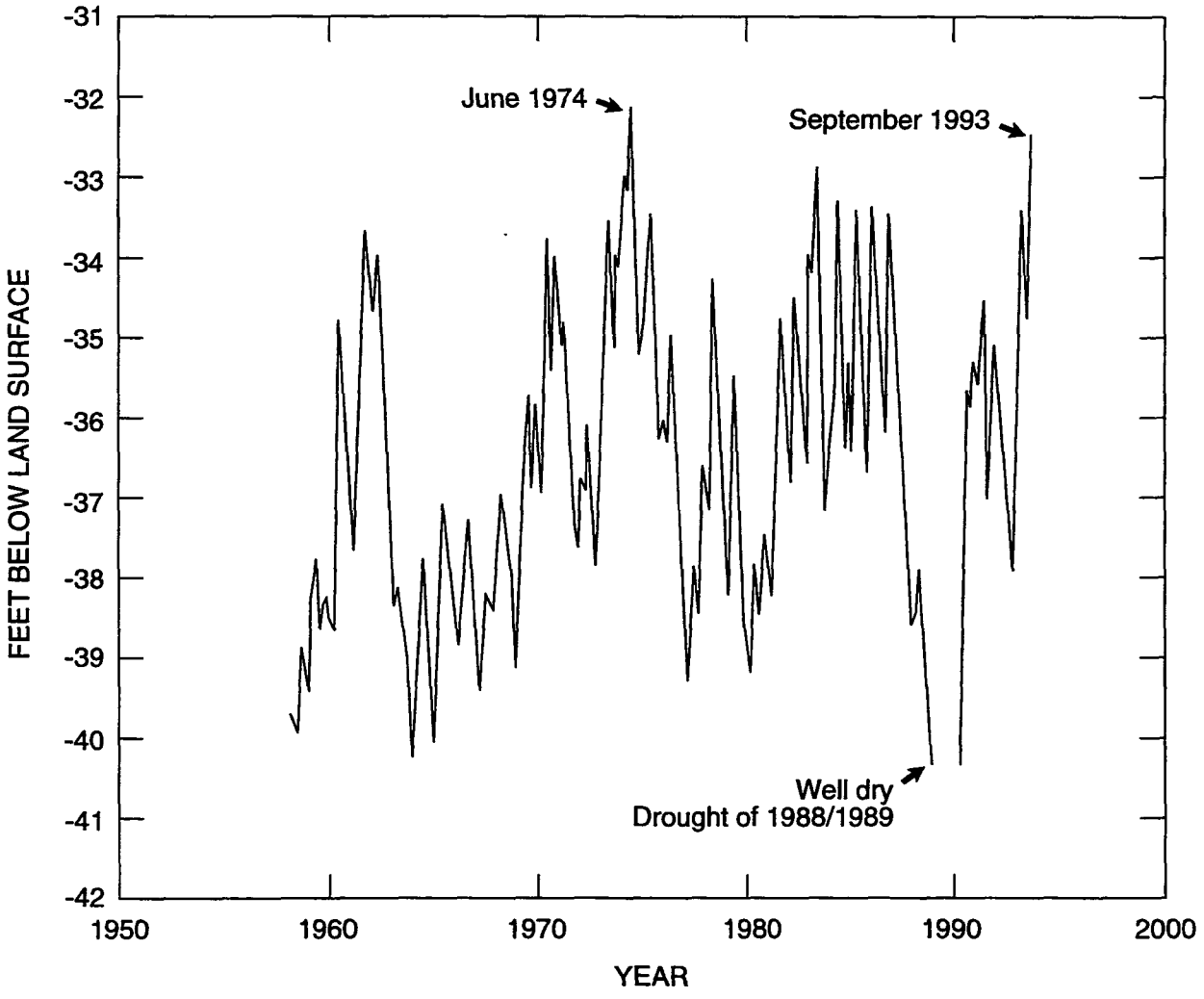


Figure 11. Ground-water levels at the Snicarte observation well in the Havana Lowlands area of Mason County near the Illinois River (from Bhowmik, et al., 1994)

from the well's hydrograph that the depth to water (feet) at the Snicarte well during the summer and early fall of 1993 was the second lowest it had ever been. The ISWS operates a network of 18 shallow wells across Illinois, and each is located so as to measure natural fluctuations in water table levels remote from private or municipal pumping facilities. Thus, this well record is further proof of the very unusual precipitation and ground-water conditions that occurred in the IVWA region during the summer of 1993.

Finally, precipitation values collected here are compared to ground-water recharge values computed by Walton (1965) for the Havana Lowlands region. Ground-water recharge is generally at a maximum during wet spring months, and in many years there is little recharge during July-November (Walton, 1965), though the wet summer of 1993 would certainly represent an exception. Recharge rates also vary in space and time, and are particularly a function of the type of soil and subsoil deposits in the region of interest. The following descriptive excerpts concerning this area come from Walton:

> "The Havana region in west-central Illinois covers about 720 square miles mostly in Mason County. The areas is bounded on the west by the Illinois River; on the east by ground-water divides which roughly trend east-northeast in the vicinity of Mason City, San Jose, and Delavan; on the north by Pekin; and on the south by the Sangamon River... The area is primarily a wide, low rolling sandy plain east of the Illinois River, bordered to the east by glaciated uplands...
>
> "...The area is a wide bedrock lowland at the confluence of the ancient Mississippi and Mahomet Rivers now buried beneath a thick mantle of glacial drift. Glacial deposits, mainly sand and gravel, include ancient stream fills and

outwash and exceed 100 feet in thickness in most of the area. Mississippian and Pennsylvanian bedrock formations, consisting mostly of shale and limestone, underlie the glacial deposits.

".. .Throughout much of the Havana region the upper part of the (glacial) deposits is composed of sand and gravel and the lower part is mainly sand. In upland areas (to the east), such as in Mason City, the sand and gravel deposits are overlain by glacial till...

"...Recharge conditions are most favorable in lowland (western) areas where the Sankoty Sand (fine sand to very coarse sand with granule gravel) is covered by Wisconsinan outwash (coarse, permeable sandy gravel) and sand dunes. Recharge conditions are less favorable in upland (eastern) areas where Wisconsinan or Illinoisan till, or both, are present. Till and silt beds of low permeability retard the vertical movement of water.

".. .Recharge rates, computed as the quotients of flow through sections and areas of flow channels, average about 270,000 gallons per day/square mile in flow channels 1 and 2 (flow channel 1 is located straddling the Mason/Tazewell line west of Manito; flow channel 2 is located between San Jose and Mason City) and about 490,000 gallons per day/square mile in flow channels 3 and 4 (flow channel 3 is located towards the Sangamon River between Easton and Mason City; flow channel 4 is located between Kilbourne and Havana towards the Illinois River). Flow channels 1 and 2 lie in areas where layers of till overlie the aquifer and retard the vertical movement of water. Flow channels 3 and 4 lie in areas where fairly coarse grained sand and gravel deposits occur from the surface down to bedrock."

Thus, given precipitation events, recharge is much greater or more efficient in the western sand/gravel region. The extremely heavy precipitation during the year in southwestern and western portions of the network area, which experienced widespread ground-water flooding and the greatest ground-water recharge, particularly occurred during the summer months when recharge is typically low. There appears then to be a fairly good relationship between the extremely heavy precipitation amounts received during the summer of 1993 and the recharge efficiency. Again, the Snicarte shallow well example indicates the record-low depth-to-water experienced in the region as a whole, which in some cases represented a ground-water surplus, flooding thousands of acres of farmland.

6. SUMMARY

Data from the first year of operation of the IVWA raingage network have been documented here, and it appears that the data collected are providing new information about the variability of precipitation in the region. The exposure and areal coverage of the network appear to adequately capture the precipitation of the region. These data, in combination with ground-water information, should greatly enhance the ability of the IVWA to accurately and efficiently manage the pumpage of water from the local aquifer.

Because of the relatively dense spacing of the raingages deployed, the network is also providing high quality data for research purposes. After the second and third years of data collection (September 1993-August 1994 and September 1994-August 1995), matrices of correlation coefficients between each raingage site will be computed on a seasonal, yearly, and uiree-year basis. The correlation analysis will help identify regions of spatial coherency in the precipitation-producing systems traversing the region, allowing a further assessment of the spatial variability of the precipitation. Estimates of the probabilities of different storm paths and

precipitation patterns in the area will also be possible, since these types of statistics become more stable as the data sample-size increases. This statistical exercise also allows an evaluation of the spacing between the raingages. The correlation values will allow us to quantify the strength of the relationship between neighboring sites, enabling an evaluation of the spacing between gages. Along with ground-water withdrawal and recharge data, these analyses should provide a unique database with which the IVWA can assess risks associated with continued irrigation development and growth in the demand for ground water.

Network operations have become quite routine, allowing final hourly, daily, and monthly precipitation totals to be available within two to three weeks after the end of a calendar month.

7. ACKNOWLEDGMENTS

This work was contracted by the IVWA under grant "Imperial Valley 223." Mr. Morris Bell, chairman of the IVWA, and his board administer the project. Doug Ward established the digitizing system, including software; Marv Clevenger and Roma Johnson handle all digitizing tasks; Linda Hascall and Dave Cox prepared the figures for this report; and Sarah Hibbeler edited the report. The ISWS and IVWA would like to take this opportunity to thank all of the local Mason/Tazewell County observers, past and present, for their diligence in making this project a success. Finally, Douglas M. A. Jones, our Champaign-based raingage technician, is greatly thanked for coming out of retirement to make the field portion of this project run smoothly.

8. REFERENCES

Bhowmik, N. G., A. G. Buck, S. A. Changnon, R. H. Dalton, M. Demissie, A. Durgunoglu, A. R. Juhl, H. V. Knapp, K. E. Kunkel, S. A. McConkey, R. W. Scott, K. P. Singh, T. W. Soong, R. E. Sparks, A. P. Visocky, D. R. Vonnahme, and W. M. Wendland, 1994: *The 1993 Flood on the Mississippi River in Illinois*. Illinois State Water Survey Miscellaneous Publication 151, 149 pp.

Huff, F. A., 1967: Time distribution of rainfall in heavy storms. *Water Resources Research,* 3, 1007-1019.

Huff, F. A., 1970: Sampling errors in measurement of mean precipitation. *Journal of Applied Meteorology,* 9, 35-44.

Huff, F. A., and J. R. Angel, 1989: *Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois*. Illinois State Water Survey Bulletin 70, 177 pp.

Jones, D. M. A., 1969: Effect of housing shape on the catch of recording gages. *Monthly Weather Review,* 97, 604-606.

Koschmieder, H., 1934: Methods and results of definite rain measurements. *Monthly Weather Review,* 62, 5.

Legates, D. R., and C. J. Willmott, 1990: Mean seasonal and spatial variability in gauge-corrected, global precipitation. *International Journal of Climatology,* 10, 111-127.

Lindroth, A., 1991: Reduced loss in precipitation measurements using a new wind shield for raingages. *Journal of Atmospheric and Oceanic Technology,* 8, 444-451.

Peppier, R. A., 1990: *Reduction of 1987 Water Year Precipitation Data for Lake Michigan Diversion Accounting*. Illinois State Water Survey Contract Report 498, 16 pp.

Peppier, R. A., 1991a: *Reduction and Adjustment of Water Year 1988 and Water Year 1989 Precipitation Data for Lake Michigan Diversion Accounting*. Illinois State Water Survey Contract Report 510, 24 pp.

Peppier, R. A., 1991b: *Installation and Operation of a Dense Raingage Network to Improve Precipitation Measurements for Lake Michigan Diversion Accounting: Water Year 1990*. Illinois State Water Survey Contract Report 517, 87 pp.

Peppier, R. A., 1991c: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1991*. Illinois State Water Survey Contract Report 520, 65 pp.

Peppier, R. A., 1993a: *Reduction of 1986 Water Year Precipitation Data for Lake Michigan Diversion Accounting*. Illinois State Water Survey Contract Report 550, 13 pp.

Peppier, R. A., 1993b: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1992*. Illinois State Water Survey Contract Report 551, 59 pp.

Peppier, R. A., 1994: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1993*. Illinois State Water Survey Contract Report 573, 60 pp.

Vogel, J. L., 1986: *Significant Storm Distribution in Chicago 1949-1979*. Illinois State Water Survey Contract Report 388, 30 pp.

Vogel, J. L., 1988: *An Examination of Chicago Precipitation Patterns for Water Year 1984*. Illinois State Water Survey Contract Report 449, 44 pp.

Vogel, J. L., 1989: *Reduction of 1985 Water Year Precipitation Data for Chicago*. Illinois State Water Survey Contract Report 459, 15 pp.

Walton, W. C, 1965: *Ground-Water Recharge and Runoff in Illinois*. Illinois State Water Survey Report of Investigation 48, 55 pp.

APPENDIX I: RAINGAGE SITE DESCRIPTIONS

Contained in this appendix are descriptions of the 25 raingage sites within the IVWA Network, current as of the publication of this report. Sites that have been relocated since the network was established in August 1992 are so noted in the "Placement" portion of each description.

SITE DESCRIPTION		
Site Number: 1		
County: Tazewell	Latitude: 40° 28' 3"	Longitude: 89° 50' 9"
Property Owner: Melvin Fornoff		
Address: 10200 Fornoff Road, Manito, IL 61546		
Telephone: 309-968-6653		
Permission Date: 8-10-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 4695	Gage ID No.: SWS 5068	Clock Mfrs. No.: 635712
Placement: Near apple/pear trees, northeast of a garage, Property on east side of 450 E in Tazewell County, north of 1000 N. Large dog! SWS services. Gage 15 meters northwest of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 2		
County: Tazewell	Latitude: 40° 28' 42"	Longitude: 89° 45' 54"
Property Owner: Ken Becker		
Address: 8479 Townline Road, Manito, IL 61546		
Telephone: 309-545-2207		
Permission Date: 8-15-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 4723	Gage ID No.: SWS 5030	Clock Mfrs. No.: BC310
Placement: In back yard (grass) near garbage burner. Property on south side of 1100 N in Tazewell County west of 900 E. SWS services. Gage 2 meters west of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 3		
County: Tazewell	Latitude: 40° 28' 56"	Longitude: 89° 37' 33"
Property Owner: Lonn Schleder		
Address: R.R. #3, 11177 S. 14th Street, Pekin, IL 61554		
Telephone: 309-348-2447		
Permission Date: 8-10-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 1463	Gage ID No.: SWS 3693	Clock Mfrs. No.: 718879
Placement: Moved on 5-13-94 to a position about 70 meters north-northeast of original position, which was in a back pasture along a wire fence between a white aluminum shed and a large tree. Present position is between a garage and another shed near a well. Property on northwest corner of the intersection of 1600 E and 1100 N. SWS services. Gage 50 meters north-northeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 4		
County: Mason	Latitude: 40° 24' 29"	Longitude: 89° 54' 41"
Property Owner: Ellis Popcorn (Maureen Hanks)		
Address: R.R. #1, Topeka, IL 61567		
Telephone: 309-535-3840		
Permission Date: 8-10-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 7382	Gage ID No.: SWS 6573	Clock Mfrs. No.: 718794
Placement: South of large white office building, between two trees in a grassy area. Property on east side of 2340 E in Mason County, northeast of Goofy Ridge. Mrs. Hanks services. Gage 10 meters south-southeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 5		
County: Mason	Latitude: 40° 24' 29"	Longitude: 89° 50' 19"
Property Owner: Joseph Meyer		
Address: R.R. #1, Box 175, Topeka, IL 61567		
Telephone: 309-968-6378		
Permission Date: 8-10-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 5985	Gage ID No.: CDA 000130	Clock Mfrs. No.: 725456
Placement: Next to stone drive in a pasture in front of house. Property on west side of 2750 E in Mason County, south of 2500 N. SWS services. Gage 3 meters east of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 6		
County: Mason	Latitude: 40° 24' 12"	Longitude: 89° 44' 6"
Property Owner: c/o Wes Hilst		
Address: R.R. #3, Box 116, Manito, IL 61546		
Telephone: 309-968-7043		
Permission Date: 8-10-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 5295	Gage ID No.: SWS 5309	Clock Mfrs. No.: B7076
Placement: Next to old farm machinery just north of garden and northeast of green shed. Property located on west side of 3300 E in Mason County just south of 2400 N. SWS services. Gage 18 meters south of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 7		
County: Tazewell	Latitude: 40° 24' 24"	Longitude: 89° 37' 29"
Property Owner: David Van Orman		
Address: 5801 Warner Road, Green Valley, IL 61534		
Telephone: 309-352-5673		
Permission Date: 8-10-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 5935	Gage ID No.: —	Clock Mfrs. No.: 718789
Placement: Moved in May 1993 to a position south of a barn with a green roof, near edge of field. Original position was 30 meters to the northeast, north of the same barn. Both positions are northwest of the house. Property located just east of Green Valley on south side of 600 N in Tazewell County, just west of 1600 E. SWS services. Gage 17 meters west-northwest of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 8		
County: Mason	Latitude: 40° 20' 32"	Longitude: 90° 1' 8"
Property Owner: Gary Blakely		
Address: R.R. #2, Box 165, Havana, IL 62644		
Telephone: 309-543-4949		
Permission Date: 8-10-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 2000	Gage ID No.: US 148085	Clock Mfrs. No.: 699575
Placement: East-southeast of house near a small tree. Property located on the north side of 1950 N in Mason County west of 1900 E. Mr. Blakely services. Gage 36 meters east-northeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 9		
County: Mason	Latitude: 40° 19' 41"	Longitude: 89° 55' 55"
Property Owner: John Crum		
Address: Box 19, Topeka, IL 61567		
Telephone: 309-535-2080		
Permission Date: 5-14-93		
Installation Date: 5-14-93		
Gage Mfrs. No.: 5986	Gage ID No.: CDA 000132	Clock Mfrs. No.: B7320
Placement: Located in a sparse apple orchard about 70 meters west of house. Original position from 8-24-92 to 5-14-93 was at R.R. #1, Box 6, Topeka, about one mile north-northeast of present position at a farmstead between a tank and a light pole along a front drive. Present location is on Pear Street in the far southwestern portion of Topeka in Mason County. From 2280 E turn west on 5th Street until you reach Pear Street. Mr. Crum services. Gage 75 meters west-northwest of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 10		
County: Mason	Latitude: 40° 19' 58"	Longitude: 89° 48' 53"
Property Owner: Paul Meeker		
Address: R.R. #1, Box 31, Forest City, IL 61532		
Telephone: 309-597-2163		
Permission Date: 8-10-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 4679	Gage ID No.: SWS 5100	Clock Mfrs. No.: 678642
Placement: West of hedge row on southwest edge of home property. Property is on north side of 1900 N in Mason County, east of 2800 E, and the gage is about 3 meters north of 1900 E. SWS services. Gage 10 meters northeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 11		
County: Mason	Latitude: 40° 20' 2"	Longitude: 89° 44' 4"
Property Owner: Louis Moehring		
Address: 32972 E. County Road 1900N, Manito, IL 61546		
Telephone: 217-482-3320		
Permission Date: 8-10-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 3362	Gage ID No.: SWS 4450	Clock Mfrs. No.: 692005
Placement: North side (back of) house along a walk. Property is on northwest corner of intersection of 1900 N and 3300 E in Mason County. Mr. Moehring services. Gage 12 meters southwest of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 12		
County: Tazewell	Latitude: 40° 20' 16"	Longitude: 89° 38' 26"
Property Owner: Harold Deiss		
Address: 1327 Route 29, San Jose, IL 62682		
Telephone: 309-247-3535		
Permission Date: 8-10-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 3346	Gage ID No.: SWS 4439	Clock Mfrs. No.: 725161
Placement: East side of Route 29 (1500 E) in Tazewell County in a grassy area southwest of a red shed. Deiss house is 1/4 mile north. Just north of Day Ditch. SWS services. Gage 2 meters south of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 13		
County: Mason	Latitude: 40° 15' 43"	Longitude: 90° 0' 48"
Property Owner: Don Hahn		
Address: R.R. #1, Box 386, Havana, IL 62644		
Telephone: 309-543-4660		
Permission Date: 8-11-92		
Installation Date: 8-25-92		
Gage Mfrs. No.: 5939	Gage ID No.: —	Clock Mfrs. No.: BC170
Placement: Left side of front entrance drive near a short fence. Property on south side of the diagonal 1450 N, east of Route 97. Mr. Hahn services. Gage 3 meters north-northeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 14		
County: Mason	Latitude: 40° 15' 52"	Longitude: 89° 56' 33"
Property Owner: Wayne Patterson (650 E. Taintor Rd., Springfield, IL 62702-1755)		
Address: RR #1, Box 220, Easton, IL 62633		
Telephone: 309-543-4664		
Permission Date: 8-11-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 4678	Gage ID No.: SWS 5098	Clock Mfrs. No.: BC206
Placement: In a small clearing north of house. Property located on west side of 2200 E in Mason County south of 1500 N. Correspondence address changed to that of Wayne Patterson on 3-26-94. SWS services. Gage 17 meters northwest of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 15		
County: Mason	Latitude: 40° 15' 27"	Longitude: 89° 50' 22"
Property Owner: c/o Joe Umbach		
Address: R.R. #1, Box 156, Easton, IL 62633		
Telephone: 309-562-7611		
Permission Date: 8-12-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 6462	Gage ID No.: CDA 000136	Clock Mfrs. No.: B7318
Placement: Along right side of the lane which extends north from 1410 N in Mason County, between Route 10 and 2800 E. 1410 N runs from southwest to northeast along Central Ditch. SWS services. Gage 2 meters north-northeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 16		
County: Mason	Latitude: 40° 16' 5"	Longitude: 89° 44' 9"
Property Owner: Donald Osborn, Sr.		
Address: 32866 E. County Road 1450N, Mason City, IL 62664		
Telephone: 217-482-5816		
Permission Date: 8-11-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 4659	Gage ID No.: SWS 5059	Clock Mfrs. No.: 659947
Placement: Along right side of drive near pig pen and road (1450 N). Property located on north side of 1450 N just west of 3300 E. Mr. Osborn services. Gage 2 meters east of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 17		
County: Mason	Latitude: 40° 16' 51"	Longitude: 89° 38' 25"
Property Owner: Larry Jennings		
Address: R.R. #1, Box 100, San Jose, IL 62682		
Telephone: 309-247-3781		
Permission Date: 8-11-92		
Installation Date: 8-24-92		
Gage Mfrs. No.: 5280	Gage ID No.: SWS 5317	Clock Mfrs. No.: BC309
Placement: West of garage near back fence and garden. Property located on 3800 E in Mason County just north of 1500 N. SWS services. Gage 34 meters west of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 18		
County: Mason	Latitude: 40° 11' 32"	Longitude: 90° 6' 15"
Property Owner: Vernon Heye		
Address: R.R. #1, Bath, IL 62617		
Telephone: 309-546-2266		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: 5278	Gage ID No.: 5308	Clock Mfrs. No.: 718982
Placement: East of white shed near field on east edge of home property. Property located on north side of 900 N in Mason County about 2 miles east of Bath. SWS services. Gage about 37 meters east-northeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 19		
County: Mason	Latitude: 40° 11' 1"	Longitude: 90° 0' 19"
Property Owner: Charles W. Lane		
Address: R.R. #1, Box 51, Kilbourne, IL 62655		
Telephone: 309-538-4397		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: 4718	Gage ID No.: SWS 5081	Clock Mfrs. No.: BC207
Placement: Along a wire fence separating home property from pig pen, northwest of house. Property located on the west side of Route 97 on southern end of a large curve between 900 N and 800 N. Mr. Lane services. Gage 14 meters northwest of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 20		
County: Mason	Latitude: 40° 11' 46"	Longitude: 89° 54' 56"
Property Owner: Wanda Krause		
Address: R.R. #1, Box 109, Easton, IL 62633		
Telephone: 309-562-7528		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: 3771	Gage ID No.: US 148830	Clock Mfrs. No.: B7747
Placement: On east side of 2400 E in Mason County near "Jon Krause" mailbox. Lane to two homes is on west side of road. Position previous to 12-93 was in a strawberry patch along the same lane about 250 meters to the west. SWS services. Gage 250 meters west of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 21		
County: Mason	Latitude: 40° 11' 10"	Longitude: 89° 49' 39"
Property Owner: John Walters		
Address: 28030 E. County Road 850N, Mason City, IL 62664		
Telephone: 309-562-7527		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: 6294	Gage ID No.: CDA 00013A	Clock Mfrs. No.: Bl853
Placement: East of the house and driveway and southeast of a shed. Property located on a hill on the northeast corner of the intersection of 2800 E and 850 N in Mason County. Position before 5-20-94 was between a windmill and a bush about 25 meters west of present position. Mrs. Walters services. Gage 25 meters east of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 22		
County: Mason	Latitude: 40° 10' 46"	Longitude: 89° 44' 28"
Property Owner: Joe Swaar		
Address: R.R. #2, Box 182, Mason City, IL 62664		
Telephone: 217-482-5571		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: 4708	Gage ID No.: SWS 5021	Clock Mfrs. No.: B7865
Placement: On a concrete slab with two 2' x 4's attached to the base of the gage, west of the house and lane on a ridge. Property is located on north side of 800 N in Mason County west of Route 29 and southwest of Mason City. Mr. Swaar services. Gage 25 meters west of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 23		
County: Mason	Latitude: 40° 12' 0"	Longitude: 89° 38' 28"
Property Owner: Dale C. Fancher		
Address: R.R. #1, Box 149, Mason City, IL 62664		
Telephone: 217-482-3506		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: 3773	Gage ID No.: US 148832	Clock Mfrs. No.: BC390
Placement: On the west edge of a garden located north of a woodshop and the house. Property located on the west side of 3800 E in Mason County about a half mile north of Route 10, east of Mason City. Mr. Fancher services. Gage 30 meters north-northwest of lat/long reading.		

SITE DESCRIPTION		
Site Number: 24		
County: Mason	Latitude: 40° 6' 26"	Longitude: 90° 11' 58"
Property Owner: Norman L. Fletcher		
Address: R.R. #1, Box 147, Bath, IL 62617		
Telephone: 309-546-2677		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: —	Gage ID No.: —	Clock Mfrs. No.: —
Placement: North of a garage near a grapevine, northeast of the house. Property located on the east side of 800 E in Mason County west of Route 78, just north of 300 N. Mrs. Fletcher services. Gage 32 meters northeast of lat/lon reading.		

SITE DESCRIPTION		
Site Number: 25		
County: Mason	Latitude: 40° 6' 14"	Longitude: 90° 8' 0"
Property Owner: Rocky Adkins		
Address: R.R. #2, Box 16, Chandlerville, IL 62627		
Telephone: 217-458-2587		
Permission Date: 8-11-92		
Installation Date: 8-26-92		
Gage Mfrs. No.: 5947	Gage ID No.: —	Clock Mfrs. No.: 628495
Placement: Next to two tanks and a sign in a small grassy area surrounded by truck access. Property located at Adkins Farms on south side of 300 N (east of Route 78) in Mason County. SWS services. Gage 2 meters south of lat/long reading.		

APPENDIX II: INSTRUCTIONS FOR RAINGAGE TECHNICIANS

A. Use Central Standard Time:

From October through March, Illinois is in the Central Standard Time zone, so the time your watch shows is the time to use when you write the time and date on the chart. From April through October, subtract one hour from what your watch says, since during the warm season Illinois is in the Central Daylight Time (Eastern Standard Time) zone.

B. Order of Servicing:

1) Old Chart

a) Unlock and open (slide up) door on the side of the instrument case and then lock door in place to prevent it from falling.
b) Depress the bucket platform casting to mark the OFF time position on the chart (a vertical trace will be written by the pen).
c) Note the time on your watch, and move the pen point and arm away from the chart by pushing out on the pen bracket.
d) Lift up on the drum cylinder that contains the chart in order to disengage it from the chart drive, and remove it out the door.
e) Remove the chart from the drum and write the OFF date and time on the chart on the red line at the right end of the chart.

2) Bucket

a) Remove the collector from the top of the gage by rotating it clockwise to disengage the tongue-and-groove assembly, set it down.
b) Carefully lift the bucket off of the weighing platform if there is water in it and dump the water on the ground.
c) Reposition the empty bucket on the platform.
d) Reinstall the collector by setting it on top of the raingage case and turning counterclockwise until the tongue-and-groove assembly meshes.
e) During wintertime operation, when a quart of antifreeze is in the bucket to prevent freezing, do not dump the bucket contents. We will monitor the increase in liquid in the bucket at the Water Survey (via the chart trace) and come to dispose of the liquid when it approaches the top of the bucket.

3) New Chart

a) Copy the OFF time from the old chart to the ON time on the new chart (another red line on end of the chart) and write your site number on the chart.
b) Clip the new chart to the drum cylinder, making sure the crease at the right end of the chart is sharp and the chart is tight on the cylinder.

c) Wind the chart drive lever until you can't anymore so that the chart drive will be ready to run again for another eight days.
d) Reinstall the chart cylinder onto the chart drive, making sure the chart cylinder and drive gears mesh. Simply push down on the cylinder and wiggle it a little. You should feel some resistance if done correctly.
e) Move the pen arm and point over to the chart cylinder with the pen bracket and rotate the cylinder counterclockwise until the pen point coincides with the correct ON time position.
f) Let the pen point rest right on the chart and depress the platform casting again to make a small vertical line denoting the ON time position.
g) When you are sure that everything is in order, carefully unlock the door, push the door down, and lock it into place for another week.

4) Problems

a) If you notice anything unusual about the gage or the chart drive operation, write a note on the upper right corner of the old chart.
b) If you think the problem requires immediate attention, call Randy Peppier collect at 217-244-1798 (day) or 217-356-6083 (night) to relay the information to him. Situations worthy of immediate attention include confusion over how to perform the operation described above, premature chart-drive stoppage, or unauthorized tampering with the gage. Immediate repairs will be scheduled if necessary.
c) Once you become experienced with this operation, it will take you less than five minutes to do it. Don't let the above instructions scare you - this operation is actually easier to perform than describe!

5. Disposition of Old Chart

a) Carefully fold the old chart and place it in one of the postage-paid envelopes provided.
b) Mail the chart to the State Water Survey:

Illinois State Water Survey
Attn: Randy Peppier
2204 Griffith Drive
Champaign, Illinois 61820-7495

C. Change in site status:

If at any time you decide that you no longer want the gage on your property or would rather that we service it, please contact Water Survey staff immediately so that they can make new arrangements. It is important to try to keep the sites in the same locations during the course of this project since rainfall generally varies greatly over short distances.

We greatly appreciate your cooperation for this project.

APPENDIX III: DOCUMENTATION OF RAINGAGE MAINTENANCE

This appendix documents most of the maintenance work carried out at each site in the network since its establishment in August 1992. Organized chronologically by site number, this documentation covers the period September 1, 1992, through September 9, 1993. All gages were installed during August 24-26, 1992. They were cleaned and lubricated, and their calibrations checked and/or adjusted, during September 8-9, 1993. These visits are not noted here unless some other type of maintenance was necessary at the time. Sites with no entries listed did not require maintenance beyond the gage cleaning and calibration activities.

SITE #1

SITE #2

7-15-93: Releveled gage.

9-8-93: Replaced collector.

SITE #3

7-15-93: Replaced pen point.

SITE #4

7-15-93: Releveled gage.

9-8-93: Replaced pen point.

SITE #5

7-15-93: Releveled gage.

SITE #6

7-15-93: Releveled gage.

SITE #7

5-14-93: Moved gage to a position about 100 feet southwest of original position.

7-15-93: Releveled gage.

9-8-93: Replaced collector and releveled gage.

SITE #8

7-16-93: Releveled gage.

SITE #9

5-14-93: Moved gage about one mile south-southwest to the town of Topeka.

9-8-93: Replaced pen point.

SITE #10

7-15-93: Releveled gage.

SITE #11

7-15-93: Releveled gage, adjusted collector.

SITE #12

7-15-93: Releveled gage.

9-8-93: Reworked gage due to flooding several days earlier. Replaced chart drive.

SITE #13

7-16-93: Releveled gage, tightened outer case.

SITE #14

9-9-93: Releveled gage.

SITE #15

SITE #16

7-15-93: Releveled gage.

9-9-93: Releveled gage.

SITE #17

7-15-93: Cleaned evaporation shield.

SITE #18

12-21-92: Rezeroed pen point.

9-9-93: Releveled gage.

SITE #19

11-9-92: Releveled gage.

SITE #20

12-21-92: Rezeroed pen point.

7-16-93: Releveled gage and rezeroed pen point.

SITE #21

11-9-92: Releveled gage.

7-16-93: Releveled gage.

12-21-92: Rezeroed pen point.

9-9-93: Releveled gage.

SITE #22

9-9-93: Replaced outer case and pen point.

SITE #23

11-9-92: Releveled gage.

12-21-92: Rezeroed pen point.

7-16-93: Releveled gage.

SITE #24

12-21-92: Rezeroed pen point.

SITE #25

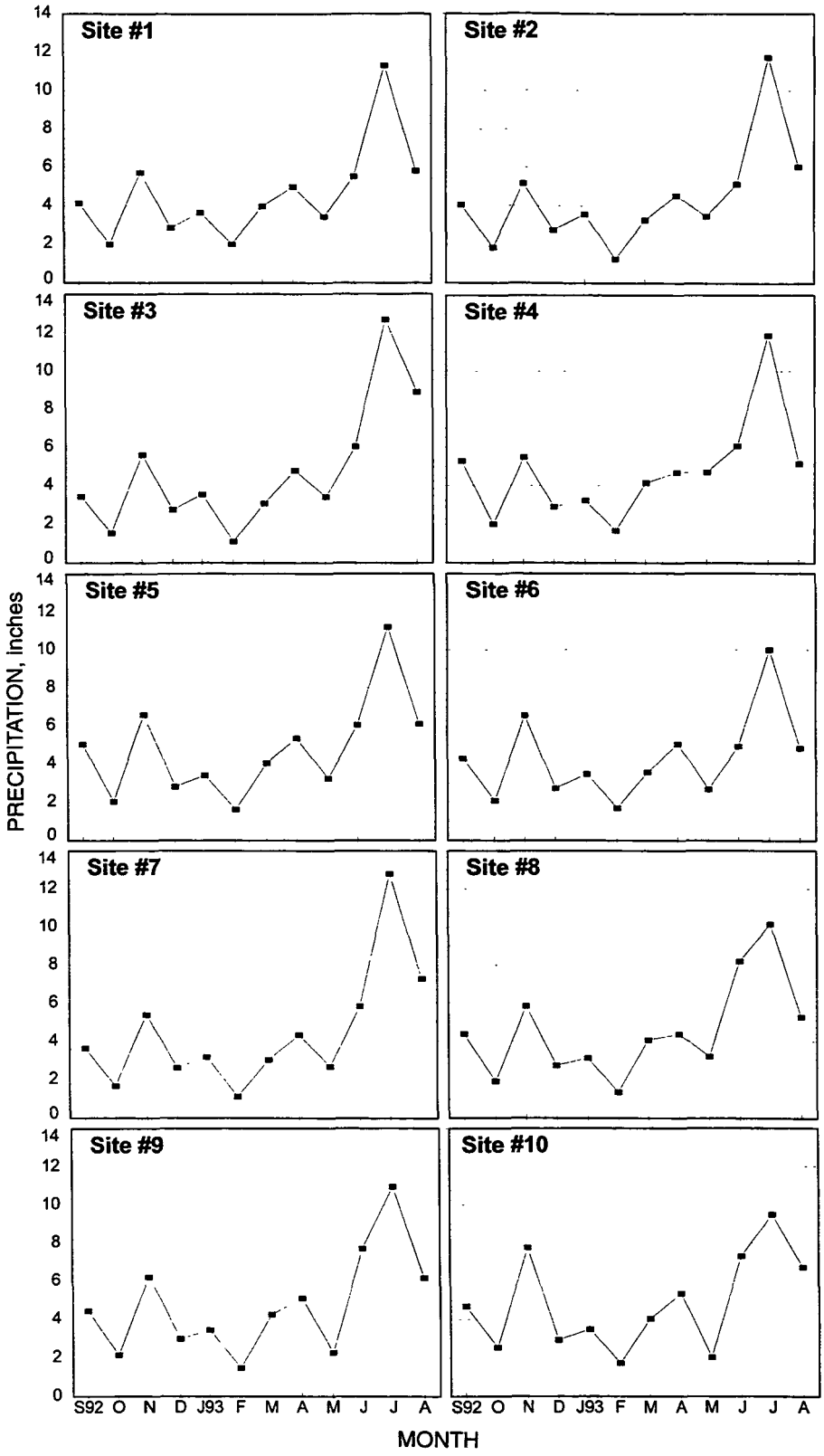
11-9-92: Releveled gage.

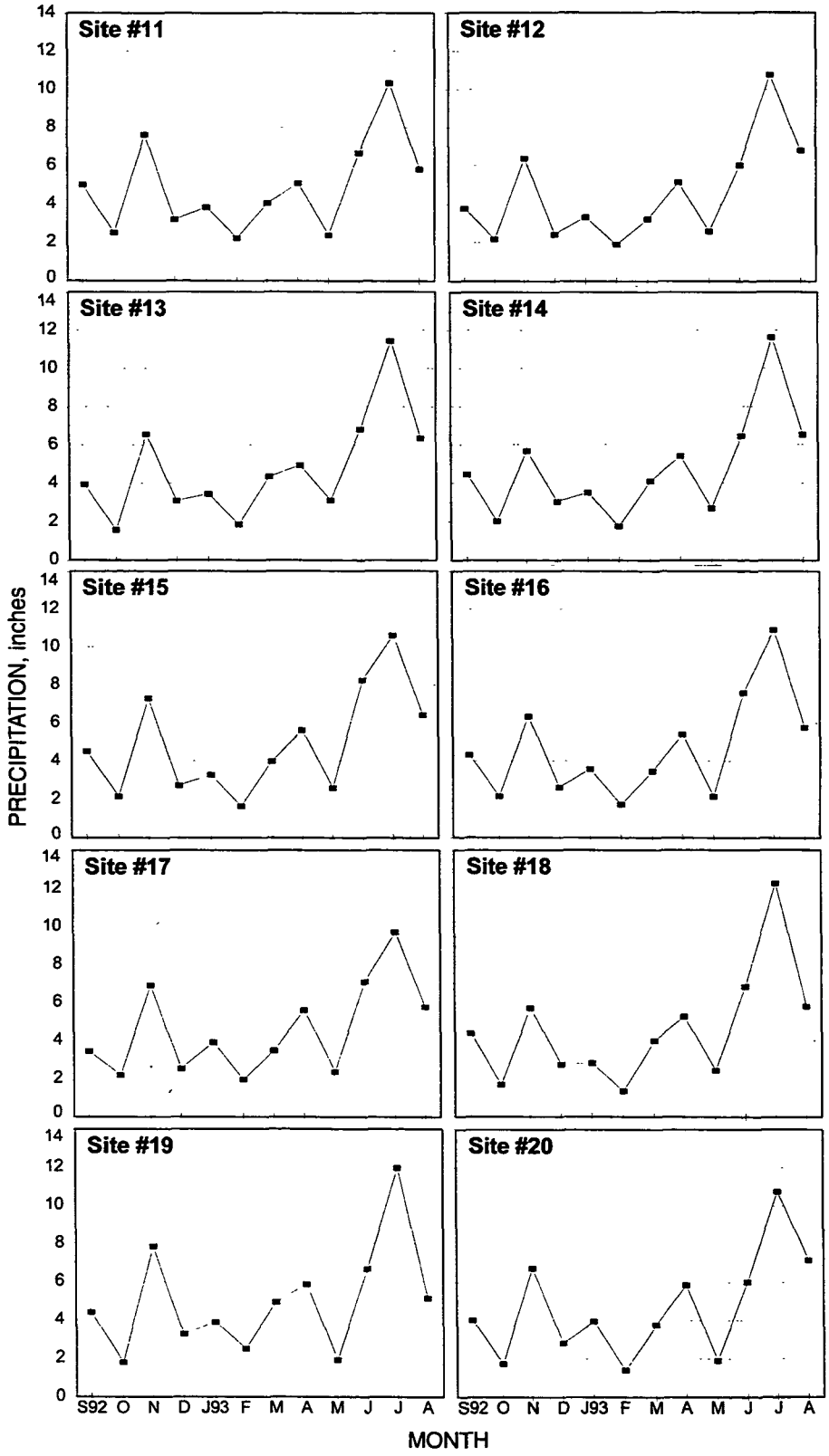
7-16-93: Releveled gage.

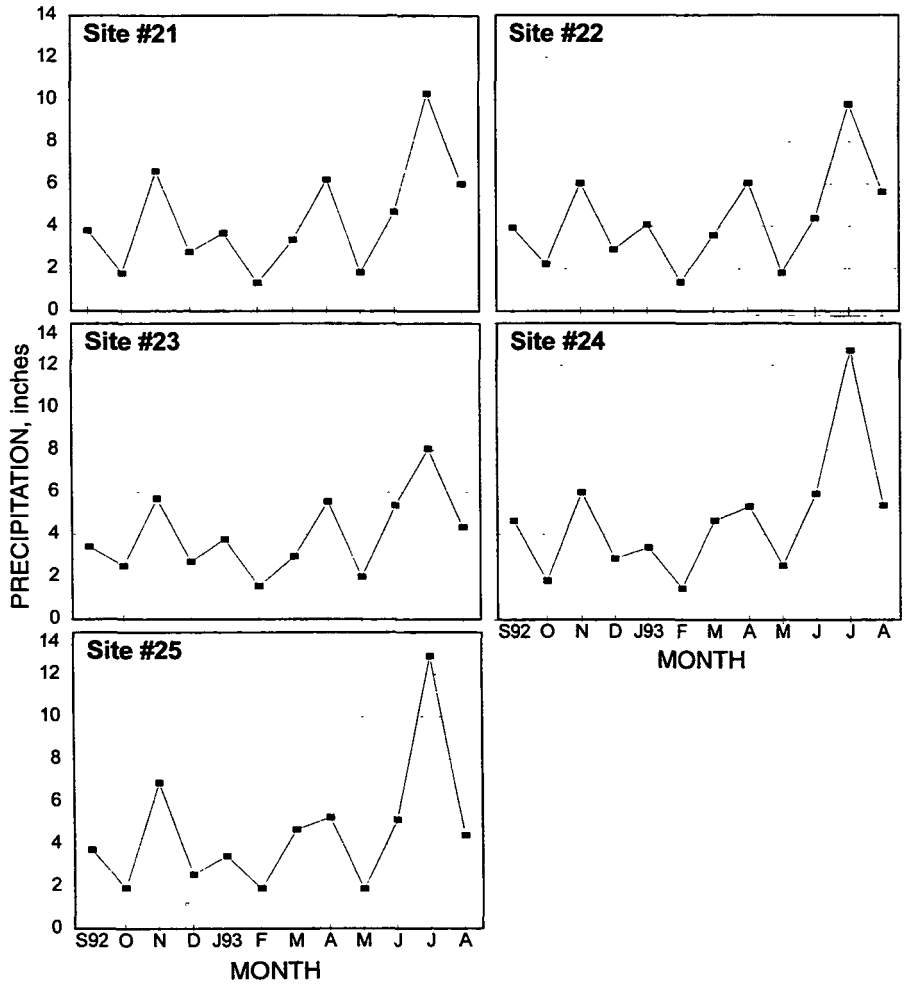
9-9-93: Releveled gage.

APPENDIX IV: MONTHLY PRECIPITATION VARIABILITY AT EACH SITE

This appendix contains graphs of the monthly variability of precipitation at each site in the IVWA Network. The graph for each site has plotted the monthly average precipitation amount (in inches) for each month from September 1992 through August 1993. Exact monthly precipitation values are contained in Table 2.


Site #1
Site #2
Site #3
Site #4
Site #5
Site #6
Site #7
Site #8
Site #9
Site #10
PRECIPITATION, inches
0
2
4
6
8
10
12
14
S92 O N D J93 F M A M J J A
MONTH


Site #11
Site #12
Site #13
Site #14
Site #15
Site #16
Site #17
Site #18
Site #19
Site #20
PRECIPITATION, inches
0
2
4
6
8
10
12
14
S92 O N D J93 F M A M J J A
MONTH


Site #21
Site #22
Site #23
Site #24
Site #25
PRECIPITATION, inches
0
2
4
6
8
10
12
14
S92 O N D J93 F M A M J J A
MONTH

APPENDIX V: DOCUMENTATION OF HIGH STORM TOTALS

This appendix documents all storm totals that exceeded an annual event (one-year recurrence interval) during the period September 1, 1992 through August 31, 1993. Storm durations of one hour to ten days were considered. The rainfall amounts for a one-year recurrence interval and the aforementioned storm durations in west-central Illinois are given below (Huff and Angel, 1989):

Storm Duration	Rainfall Amounts (inches)
1 hour	1.18
2 hours	1.48
3 hours	1.61
6 hours	1.89
12 hours	2.17
18 hours	2.28
24 hours	2.52
48 hours	2.81
72 hours	3.05
5 days	3.48
10 days	4.29

The values listed in the following table exceed the numbers above for the given storm duration. An "E" indicates a partial or full estimate for a particular site and storm. The last column indicates whether a particular storm during the year exceeded events greater than an annual event (2-year to 100-year recurrence intervals considered).

STORM TOTALS

Storm #	Site#	Date	Duration (hours)	Amount finches)	Other Events Exceeded
4	24	9/7-8/92	2	1.83	2-year
18	10	10/31-11/2/92	29	3.21	2-year
	11		33	3.39	2-year
	15		29	3.08	
	17		22	2.80	
	20		30	2.77	
	21		29	2.59	
78	4	5/28-29/93	10	2.09	
87	13	6/24-25/93	8	2.09	
90	8	6/30/93	6	2.06	
	9		7	1.86	
	10		6	1.94	
	11		4	1.82	
	16		8	3.29	5-year
	17		4	2.24	2-year
91	22	6/30-7/1/93	11	2.17	
	24		13	3.03	2-year
96	10	7/10-11/93	3	2.19	2-year
	11		6	2.57	2-year
99	2	7/13/93	2	1.55	
	7		2	1.80	2-year
	12		5	2.22	2-year
	16		4	1.67	
106	2	7/23/93	14	2.37	
	3		13	2.62	
	18		10	3.37	5-year
	19		10	2.67	2-year
	25		9	2.19	

STORM TOTALS (Concluded)

Storm #	Site#	Date	Duration (hours)	Amount (inches)	Other Events Exceeded
107	13	7/24/93	4	1.79	
	24		4	1.96 E	
	25		4	2.12	2-year
111	9	7/31-8/1/93	4	2.08	2-year
	14		4	1.85	
	21		4	1.71	
124	3	8/23/93	6	2.17	
	9		5	1.80	
	10		5	2.30	2-year
	11		6	2.22	
	13		5	2.00	
	14		5	2.11	
	15		5	2.34	2-year
	18		5	1.97	
	20		5	2.00